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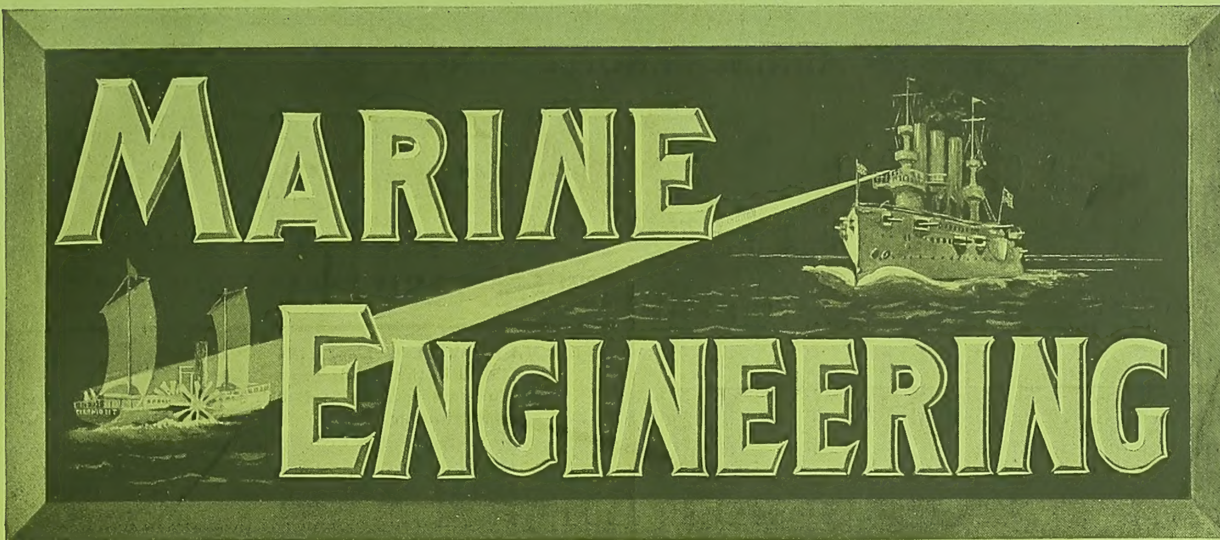

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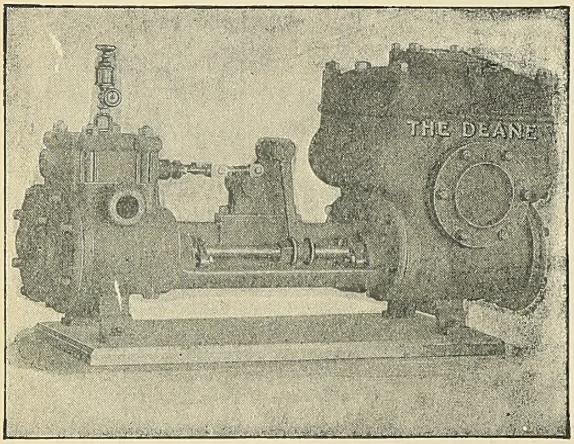

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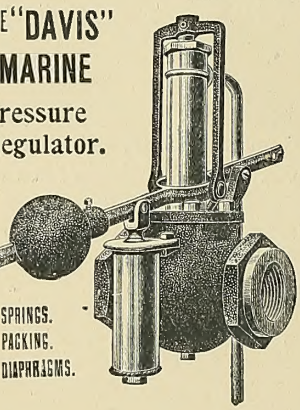

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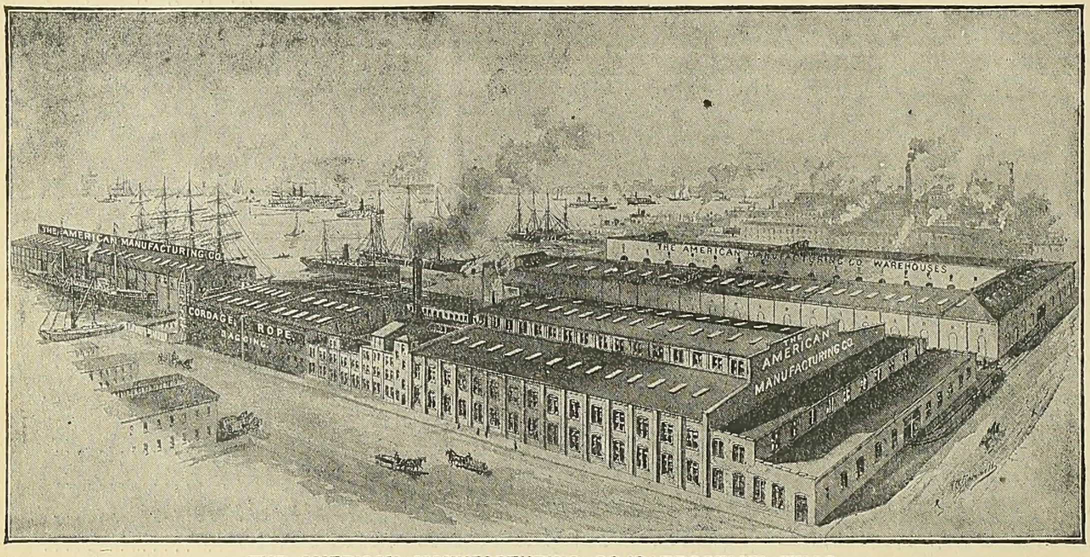

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MARINE ENGINEERING.

Vol. 3. NEW YORK, JANUARY, 1899. No. 1

PARSONS' EXPERIMENTAL BOAT TURBINIA WITH RECORD OF 32.75 KNOTS.

Our illustration shows the fastest boat in European waters—the Parsons experimental boat Turbinia—exhibiting her paces to a number of experts, who were stationed on the boat from which the photograph here reproduced was taken. The boat was running at her maximum speed, and though the photograph was of necessity made with the briefest exposure the details are wonderfully distinct. Our regular readers will recollect the description of this boat published in previous issues. She is 100 ft. long, 9 ft. beam and displaces 44 1-2 tons, and the "go-ahead" turbines develop 2,100 I. H. P. Many exaggerated statements regarding the speed of this boat have appeared in print, but the official speed, and that claimed by the inventor, the Hon. Charles Algernon Parsons, is 32.75 knots. The Parsons Marine Steam Turbine Co. has now a large works at Wallsend-on-Tyne, England, and has already booked orders for destroyers of the highest speed.

PARSONS' 100-FT. EXPERIMENTAL BOAT TURBINIA STEAMING "FULL SPEED AHEAD."
(Photo. by West, Southsea.)

FRAGMENTARY REMARKS ON THE WATER-TUBE BOILER IN MARINE WORK.

BY WILLIAM BURLINGHAM.

In full-powered vessels the use of the water-tube boiler in this country has been extremely limited. There are many builders of water-tube boilers here, and in yachts, river craft and small vessels of various types, their boilers, chiefly of the small tube variety, have been extensively installed. Many manufacturers make excessive claims which are not made good in practical every day use; and faulty design, and the inexperience and prejudice of engineers and firemen have contributed greatly to the slowness with which the water-tube boiler has been taken up. This type of steam generator has suffered from the disadvantage also, from its birth, of direct comparison with the Scotch boiler, which in its present form is the result of slow evolution from crude beginnings.

Three examples of the largest water-tube boiler installations in this country are those of the steamships Northwest and Northland on the Great Lakes and the La Grande Duchesse on the Atlantic coast. The two first named are fitted with Belleville boilers and the latter was fitted with Babcock and Wilcox boilers. Considerable difficulty was experienced in the working of the boilers of the Northwest and Northland, and in the case of the La Grande Duchesse her water-tube boilers were removed after about a year's trial and replaced with Scotch boilers fitted with Ellis & Eaves induced draft.

To get the utmost efficiency from a water-tube boiler installation the entire machinery outfit must be designed for a high pressure. To use an engine, for example, that could be as readily furnished with steam by a Scotch boiler means that one-half of the plant is so heavy that little is gained in the direction of saving of weight, and one of the greatest advantages to be derived from the use of the water-tube boiler is thus neutralized. A type of engine following the designs now universally used in naval vessels appears to be the most suitable. Two principal sources of trouble, so far as the main engines are concerned, accompany the use of high pressure steam. They are: first, the actual increased pressures, and, second, the greater temperatures occasioned. As to the first, we are not yet near the point where the resulting stresses are too great for the present materials of construction, and so we can provide by suitable design for all the effects which result from the statical pressure of the steam.

The second source of trouble, temperature, is lessened by the fact that its rate of increase is rapidly diminished as the pressure is increased, as for instance the same increment of temperature, 38.1 degrees, that causes the pressure to rise from 90 lbs. to 150 lbs. is sufficient to cause an increase of pressure from 210 to 320 lbs., and we have several steamers working satisfactorily at 200 lbs.

Superior design has provided for efficient pipe joints and gland packings. The pipe joints of the British cruisers Powerful and Terrible have proven excellent, and are made by the insertion of a ring of copper wire between the two steel or composition flanges, the setting up of the bolts, slightly flattening this wire, produces a permanent joint. This joint is also used for the bottom of the cylinder liners.

The Engineer-in-Chief of the British Navy has made a series of careful experiments as regards the strength of various materials and alloy when subject to high temperatures; in many cases 1,300 deg. Fah. was reached. The general results are summed up thus:

The ultimate strength of gun metal, copper, naval brass and manganese bronze is reduced; for mild steel, it may safely be assumed that up to 800 deg. Fah. there is no loss of strength. At a temperature of 400 deg. the loss, in Government composition (88 copper, 10 tin, 2 zinc) is from 10 to 15 per cent. Lead will make such alloys very unreliable. At the same temperature the losses sustained by other metals are: Naval brass, 5 per cent; manganese bronze, 8 per cent; copper (ordinary), 7 per cent; copper (compressed), 11 per cent. For mild steel, some Portsmouth experiments gave 7 per cent. At 400 deg. the principal loss is sustained by composition, but the reduction does not exceed 2 tons out of an original 14 tons.

Under normal conditions, the temperature of the machinery and boilers will not exceed the temperature of the steam in the water-tube boiler, and as this is raised but 35 deg. or so, in going from 200 to 300 lbs. pressure, we need have no feeling of doubt as to the strength of our materials.

The two principal reasons for the use of the water-tube boiler in the merchanat marine are: first, the immense saving in weight, and, second, the increase in economy by the use of high pressure steam.

As to the question of economy, probably the experiments of the British Admiralty committee are the most exhaustive, embodying, as they do, the results of over 500 trials of ninety-five ships. The trials were all over twelve hours' duration, under ordinary service conditions, in all parts of the world and with coal of ordinary quality. These trials have shown that about 90 per cent of the theoretical gain due to the use of increased pressures has been realized in practice, and we are, thereby, safe in assuming that an increased gain will be realized at the higher pressures of water-tube boilers. Briefly, 8 per cent was gained by the use of steam of 150 lbs. pressure, and a gain of 12 1-2 per cent is expected from a pressure of 250 lbs.

Although in many ways defective, the water-tube boiler as it now exists is steadily coming into favor, and will no doubt in time supplant the Scotch type for all services. The new battleships and monitors for the Navy will probably be equipped with water-tube boilers of the large tube type. Already the small tube type of boiler has been extensively used in torpedo vessels here. The Thornycroft has been the favorite type with our builders for this work and a brief sketch of the changes that have taken place in its design during the past few years may be of interest. This type will probably be used on the majority of the torpedo boats and destroyers building under the last Congressional appropriation.

Fig. 1 shows the original commercial type of the

Thornycroft boiler as used in the British torpedo boat Speedy and her class. This is also used on the United States boats Cushing, Ericsson, Davis, Fox, Mackenzie and McKee.

In 1893 it was fitted on the Speedy and from her trials the I. H. P. per ton of boilers and water was found to be 52.8. Since 1894 she has been employed in actual service with the Channel Squadron and excellent reports have been received of her behavior, although the tubes are gradually corroding and will have a life of about 4 1-2 to 5 years. This is less than we credit tubes with, but in the face of the British experience it is not safe to assume that they will last longer.

These boilers cannot be worked at a high rate of power with much salt in the feed water, a feature common to all small tube water-tube boilers, and special care is therefore necessary that all the joints of the feed water system exposed to salt water are well packed.

The chief objections to the "Speedy" type of boiler consisted in the length necessary to allow for the return of the downcast pipes, the small height of the furnace, and the inaccessibility of the tubes. Subsequently a new model was constructed for the "Daring" type of British destroyer and took its name from that boat.

These were of less weight comparatively, had greatly improved furnaces, and the tubes were much more accessible. The grate area, considering the available space and the heating surface, was increased enormously. Fig. 2 shows the type which is also used in the U. S. destroyers Farragut, Stringham, and Goldsborough.

An improved "Daring" type now called for on our latest torpedo boats is shown in Fig. 3. In this type the side water drums are made 18 in. dia. instead of 7 1-2 in. as in the original "Daring" class. This is supposed to allow of easier access for expanding and plugging the tubes. It is an open question, however, whether this compensates for the loss of grate area in the boiler. As a special tube expander must be used in either case, an 18 in. hole being too small for a man to do any work, it would seem better to invent a tube expander and plugger that would do the work perfectly than to lose this valuable grate area.

FIG. 1.—"SPEEDY" TYPE.

After the Thornycroft, the boiler of the small tube type with which the British have had the most extensive experience is the Normand, controlled in Great Britain by Laird Bros. and J. & G. Thompson. This type has given satisfaction in all cases where

DIMENSIONS, ETC., THORNYCROFT "SPEEDY" BOILERS.

Total I H.P.	Dimensions Over Casings.			Tube Surface, Square Feet.	Grate Area, Square Feet.	Weight with Water to Working Level, Tons.	Air Pressure in Stoke Hold.	Steam Pressure on Trial.
	Length.	Height.	Width.					
39	37 in.	31½ in.	48 in.	139	3.3	0.7	Chimney blast	145
46.7	54¾ in.	62 in.	55 in.	460	6.0	2.21	0.38	130
58	60⅛ in.	96 in.	70½ in.	586	12.0	3.78	Chimney blast	...
189	68 in.	72 in.	57 in.	774	8.5	4.3	2.16	145
194	69 in.	73 in.	56 in.	777	8.5	3.28	3.10	150
250	61 in.	80¼ in.	77½ in.	776	11.4	4.3	2.33	140
300	74 in.	90¾ in.	87 in.	1066	18.0	6.0	....	...
384	65 in.	79 in.	80 in.	937	13.0	4.53	3.41	250
400	82 in.	81 in.	66 in.	930	16.0	3.0	2.5	150
450	95 in.	98½ in.	8 ft. 10½ in.	1640	32.0	8.0	....	...
588	8 ft. 8 in.	9 ft. 3 in.	8 ft. 0 in.	2144	25.5	11.22	1.7	194
650	7 ft. 5 in.	8 ft. 11 in.	9 ft. 7 in.	2175	30.0	9.805	1.6	...
825	8 ft. 2 in.	9 ft. 0 in.	9 ft. 6 in.	2418	37.75	11.01	4.0	149
850	9 ft. 0 in.	8 ft. 9 in.	9 ft. 9 in.	2360	39.0	13.75	2.5	250
930	8 ft. 2 in.	9 ft. 1 in.	9 ft. 4 in.	2398	37.75	11.665	2.37	217
1242	8 ft. 2 in.	9 ft. 6 in.	9 ft. 0 in.	2583	36.8	13.565	2.5	205
1496	9 ft. 6¼ in.	10 ft. 2½ in.	13 ft. 3 in.	3095	63.0	15.66	2.75	209
1548	10 ft. 6 in.	10 ft. 6 in.	13 ft. 0 in.	2964	63.0	16.79	3.15	204
1867	11 ft. 6¾ in.	10 ft. 8½ in.	12 ft. 11⅞ in.	4020	65.3	18.63	3.5	211

FIG. 3.—IMPROVED "DARING" TYPE.

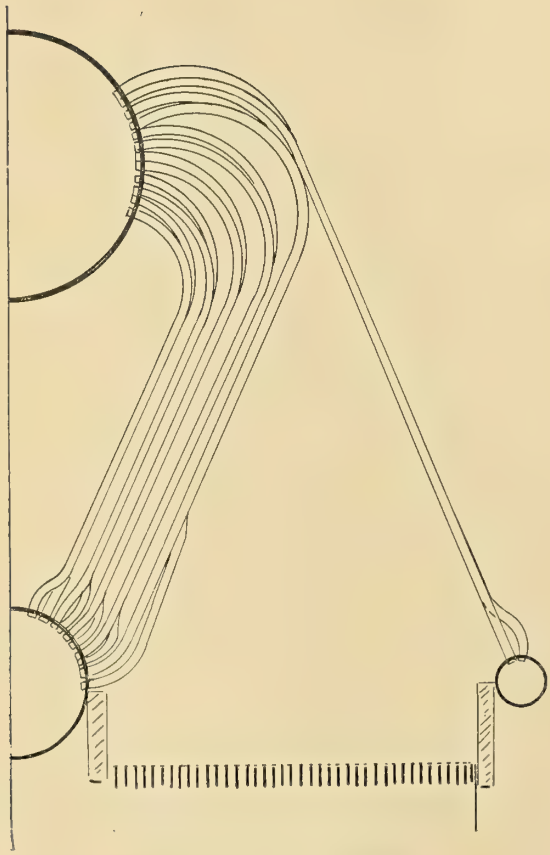


FIG. 2.—"DARING" TYPE.

steel tubes have been used, and is shown in Fig. 4. In the U. S. Navy the torpedo boats Porter, Dupont, Dahlgren, T. A. M. Craven, Morris and Gwin are fitted with these boilers.

Of the American small tube boilers, the Mosher is used in the torpedo boats Foote, Rogers, Winslow and Rowan, and the Seabury in the destroyer Bailey. The Ward type of boiler is used on the monitor Monterey, and in practically all the steam launches of our Navy.

A word or two as to the material of the tubes: In the English boat Lynx, fitted with four Normand boilers, a defective steel tube split, and the feed pump being common to two boilers, the effort of the water tender to keep up the water level of the split tube boiler, gave it all the water, the feed valves being wide open and the pressure low; consequently the water became so low in the other boiler that the tubes were overheated, reaching about 700 deg. Fah. The split tube boiler was then shut off and the water pumped into the overheated boiler; the upper part of this boiler then leaked considerably, but the tubes were little distorted, and the only repairs necessary were re-expanding throughout the upper joints of the tubes.

A more recent case occurred on the British boat Hardy, fitted with a Thornycroft boiler. The water in this boiler being allowed to get very low, caused overheating of the tubes, eventually blowing one out of the steam drum. After plugging up this particular tube, the boiler needed no further repairs, the distortion of the tubes being insignificant. From an examination of these tubes the water level was shown to have fallen to such an extent that if it had occurred in an ordinary Scotch boiler it would have assuredly caused the dropping of the crownsheets and furnaces.

In many of the original British destroyers the boiler tubes were of copper. The great trouble with these was that they would split or bend and the tubes near the fire would warp out of shape. Examination showed the burned and deteriorated character of the metal and its unsuitability for such conditions. As the split tubes were found to be next the fire, four rows of solid drawn steel tubes were substituted, and on service this worked all right for a time, but when the copper tubes became dirty, more or less trouble was experienced with them, and eventually all the tubes were made of solid drawn steel. Our own gunboat the Nashville has copper tubes in Yarrow boilers, and these are giving the same trouble that the English experienced; they will shortly be taken out and solid drawn steel tubes substituted.

Two or three cases of splitting have occurred with these steel tubes, but all have been traced to original defects of the material.

The tests of the Admiralty as given by Mr. Oram, Senior Engineering Inspector of the British Navy, are as follows: Each tube is tested to 1,500 lbs. per sq. in. by water pressure, and various expanding and flattening tests are applied to a certain percentage of them, to show their ductility and other working qualities.

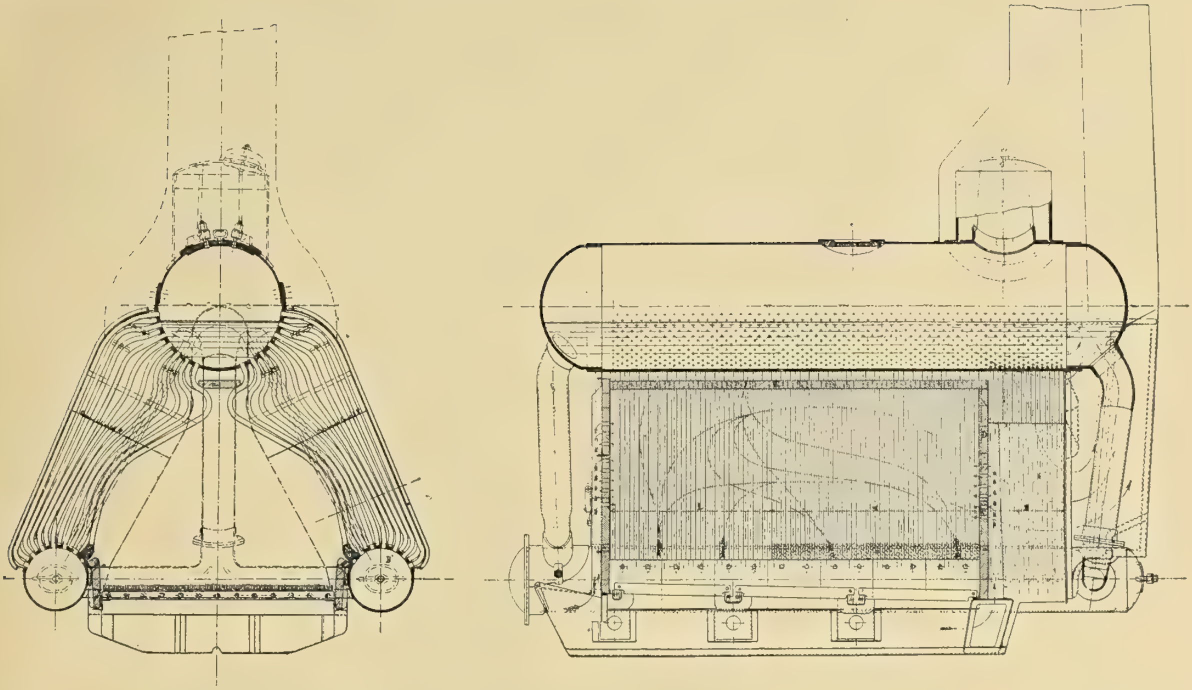


Fig. 4.—NORMAND WATER-TUBE BOILER.

The United States Navy specifications for tubes are very similar. The tubes are first inspected for surface defects, etc., tested for gauge and then from every lot of 100, four tubes are taken at random, and subjected to the following tests:

(1) The open end of one tube, after annealing, is flattened by hammering until the sides are parallel, the inside radius of the corners of the tube being equal to twice its thickness.

(2) A piece, one inch long, after annealing must stand crushing, in the direction of its axis, under a hammer, until shortened to 1-2 in.

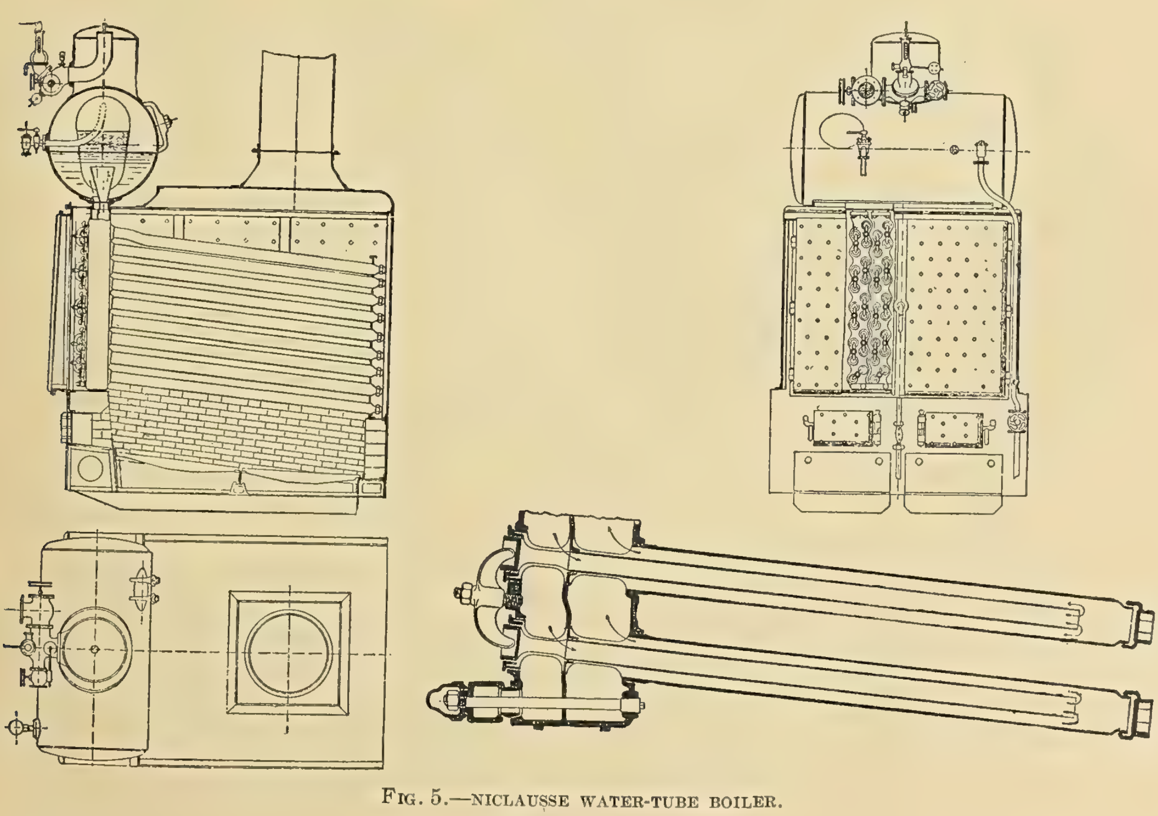


Fig. 5.—NICLAUSSE WATER-TUBE BOILER.

(3) The open end of one piece, cold after annealing, shall have a smooth taper pin, taper 1-2 in. to the foot, driven into it, until the end of the piece stretches to 1 1-8 times the original diameter.

(4) The open end of one piece, heated to a bright cherry red in daylight, shall have a smooth taper pin, 1 1-2 in. taper to the foot, heated to a dull red heat in daylight, driven into it, until it stretches to 1 1-8 times its original diameter.

Each tube will be accepted, up to 8 per cent above the standard weight for the gauge ordered. Each

DIMENSIONS, ETC., NORMAND WATER-TUBE BOILERS.

	Long and Low Type	Short and High Type	Long and Low Type	Short and High Type
Length over all	13 ft. 1 in.	11 ft. 8 in.	13 ft. 3 in.	11 ft. 6 in.
Height over all	10 ft. 6 in.	11 ft. 10 in.	11 ft. 3 in.	12 ft. 8 in.
Width over all	9 ft. 6 in.	9 ft. 5 in.	11 ft. 2 in.	11 ft. 0 in.
Tubular heating surface	1,830 sq. ft.	1,830 sq. ft.	2,360 sq. ft.	2,360 sq. ft.
Grate surface	38 sq. ft.	38 sq. ft.	45 sq. ft.	45 sq. ft.
Pressure	200 lbs.	200 lbs.	200 lbs.	200 lbs.
Approximate weight without water for light steamers, torpedo boats, etc.	23,408 lbs.	22.960 lbs.	27,236 lbs.	26,900 lbs.
Ditto for larger steamers, cruisers, etc.	25 5?0 lbs.	25.322 lbs.	29,934 lbs.	29,54- lbs.
Weight of water	5,892 lbs.	5.488 lbs.	6,832 lbs.	6,385 lbs.
Total weight in each case, light steamers	29.300 lbs.	28,448 lbs.	34.068 lbs.	33.285 lbs.
Total weight in each case, larger steamers	31.422 lbs.	30,810 lbs.	36,766 lbs.	35,933 lbs.

tube must be subjected to 1,000 lbs. internal hydrostatic pressure.

These tests must be passed by the tubes without showing cracks, flaws or weakness.

It is the English practice, to galvanize all tubes externally, with a view of preventing external corrosion, and this process brings out defects that are

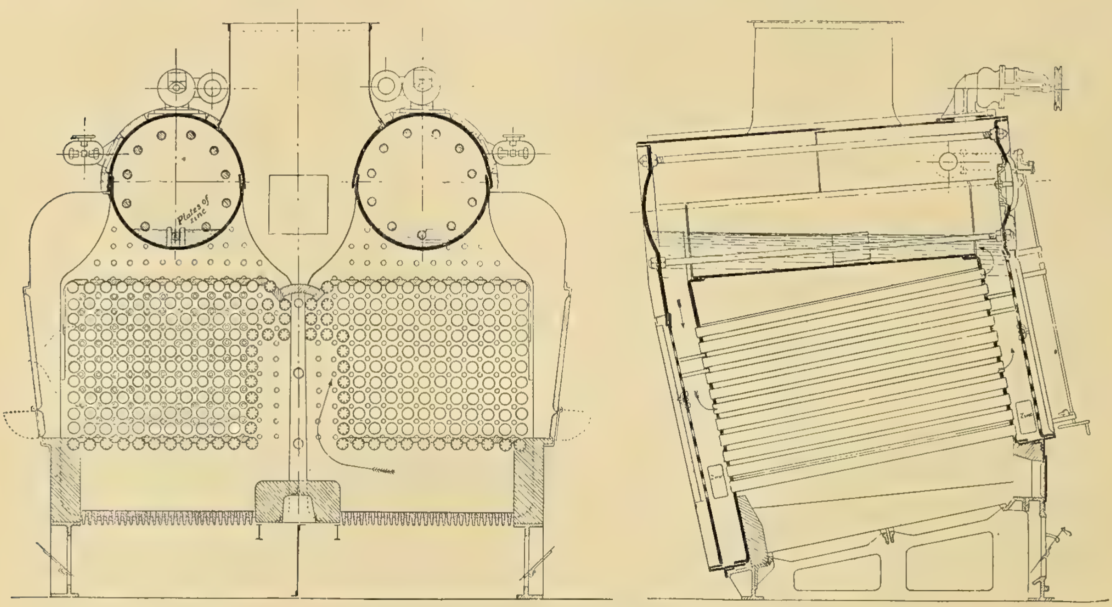


Fig. 6.—D'ALLEST WATER-TUBE BOILER.

not revealed in ordinary examination. The tubes are first pickled in weak acid, removing all scale, then a coating of 1 1-2 oz. of zinc per square foot is added.

Experiments of the English Admiralty, as given by Mr. Oram, regarding the steam pressure necessary to burst sound tubes, are of interest in this connection.

A copper boiler tube, 1 in. external diameter and .07 in. thick, was partly filled with water, the ends closed and the tube inclined at an angle of 20 degs. to the horizontal. On being heated by a blast, the pressure rapidly rose to about 2,000 lbs., the tube bursting 6 1-2 minutes after the pressure first appeared on the gauge. The entire portion that had been subjected to the heat was found to have been split open and practically flattened. This pressure would correspond to a stress of about 6 1-2 tons per sq. in. and a temperature of steam of about 640 degs.

A similar experiment was made with a new steel tube, 1 1-4 in. dia. and .104 in. thick, which had been formed into a spiral 6 in. dia. This tube was one-half filled with water and burst at 4,788 pounds per sq. in. It was flattened out locally, but not nearly so extensively as in the case of the first one. The stress per square inch was about 12 3-4 tons, and the steam temperature 800 degs.

The experiments show that sound tubes require a considerable pressure to burst them, and while steel tubes do not suffer materially, there is no doubt but that copper tubes get sufficiently hot to lose their strength.

Of the large tube type of water tube boiler there is but little data in this country to guide us in the choice of a suitable type.

This has given rise to a great variety of opinion about the merits of this type of boiler, with reference especially to the equipment of the new battleships and monitors.

The Belleville is the boiler that is extensively used in the British Navy, and is fitted in the cruisers Powerful and Terrible. A later type of the same boiler has been installed in the "Diadem" and the boats now under construction. The later type is the one fitted with the economizer above the usual elements thus forming a combustion chamber above the water tubes for thoroughly mixing the gases before they impinge on the tubes of the economizer. The Belleville boiler has been in use since 1886 in the Messageries Maritime, a prominent French line, and is apparently very satisfactory. A British officer was sent on a voyage in one of the company's boats to Australia and back, and his report was entirely favorable; so much so, in fact, that this, with the experience of Sir John Durston, was sufficient to insure their adoption in the British Navy. Our own reports of this type are not so favorable, and this, in conjunction with the fact that a number of auxiliaries have been found necessary for the successful working of this boiler, has delayed its adoption in this country.

It might be asked, had the Niclausse or Lagrafel D'Allest boilers been taken up by the British and nursed as carefully as the Belleville, would they not have given as good or better results? These boilers, in fact, will work without the assistance of any auxiliaries other than the usual feed pump.

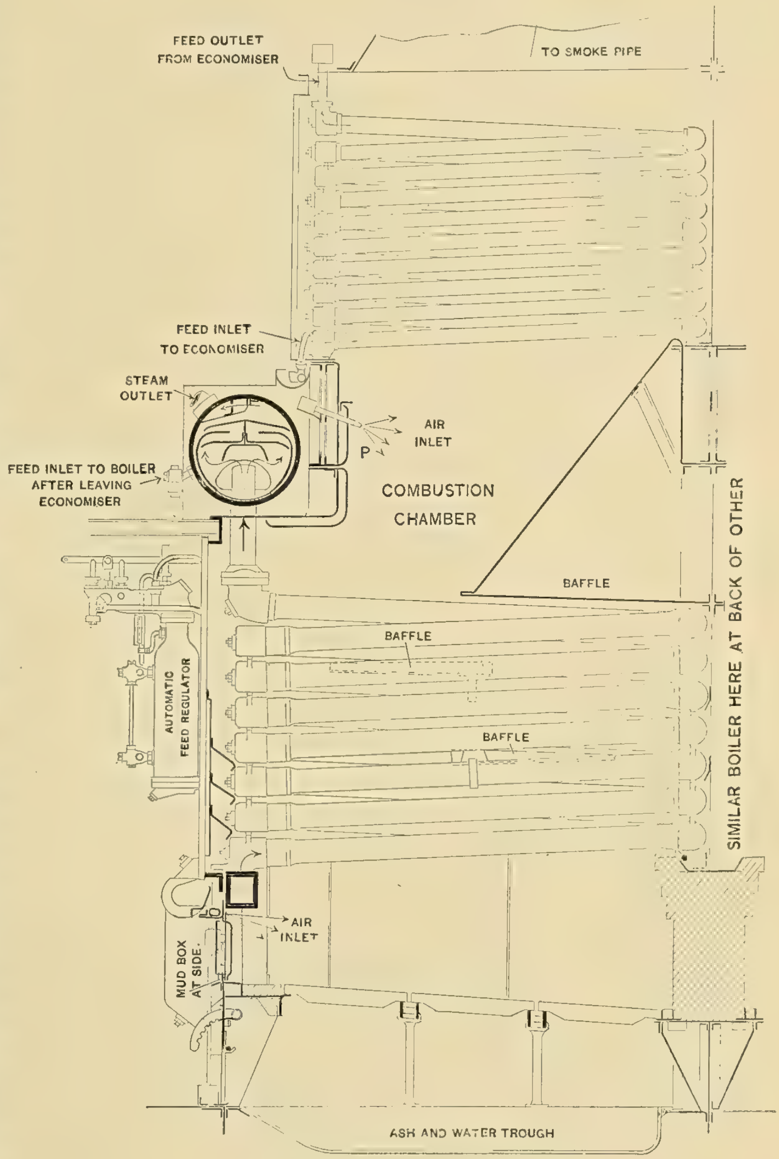
The Niclausse boiler, Fig. 5, is used more extensively in France than elsewhere, although Messrs. Humphreys, Tennant & Co. are installing a set in the British ship Seagull, and the Russians have several thousand horse power in use. The majority of the reports from the ships using them speak of the boiler as doing very satisfactorily. A well known American shipbuilder will probably use this type of boiler in one of the new battleships.

The Lagrafel D'Allest boiler, Fig. 6, is almost entirely limited to the French Navy, and is a good second to the Belleville, the D'Allest having over double the horse power in use that is credited to the Niclausse, a fact hardly realized in this country. A statement of the total horse power of these three boilers, as used in the navies of England, Russia and France, is shown in the next column.

These figures are practically correct and show the preponderance of the Belleville type. They represent merely the horse power of the battleships and cruisers, small vessels not having been taken into account.

Navy	Belleville	Niclausse	Lagrafel D'Allest
Russia.......	146,900	5,000	Unknown but small
England.....	182,000	3,500	Unknown but small
France	217,400	70,000	165,400

The Lagrafel D'Allest is probably the best of the attempts to secure a substitute for the Scotch boiler. This boiler is not quite so heavy as the Belleville, but the floor space occupied is greater for the same area of grate or heating surface; as, however, the D'Allest is much more capable of being forced than the Belleville, for the maximum power, the space occupied by the former is no greater than the latter. The cost of operating the D'Allest is less, and the amount of water it contains, although not so much as in the ordinary Scotch boiler, is yet enough to do away with



BELLEVILLE WATER-TUBE BOILER.

an automatic feed regulator and its necessary complications. The Belleville, however, has the advantage of freedom of the tubes for expansion, thus reducing the danger of leaks. The weight of the Niclausse and D'Allest is practically the same, for the same area of heating surface, but the Niclausse is not capable of the high forcing of the D'Allest. The lower rows of tubes in the Niclausse are more liable to burn out than those in the D'Allest, the peculiar construction of the former boiler precluding the use of Serve tubes. Both of these boilers give dry steam at high pressures, a point of advantage that is lacking in the Belleville. The economy of the D'Allest is better than either of the other two, and much nearer the Scotch boiler.

It seems extraordinary that we have no large-tube water tube boiler for marine use in this country that occupies the position in the eyes of the world that foreign (especially French) boilers do. There is a grand field open to the American who can furnish such a boiler, and there would seem thus to be a great opportunity for the competent engineeer to design a steam generator that would fill the present requirements. Of the small-tube variety there are many American boilers on the market which are probably as good as any of the foreign ones of their classes.

First Large Merchant Steamship Constructed in Japan—the Hitachi Maru.

The passenger steamship Hitachi Maru recently launched at the Mitsu Bishi Dockyard, Nagasaki, marks a distinct advance in Japanese shipbuilding. This vessel, which was built for the Nippon Yusen Kaisha (Japan Steamship Co.), is of the following dimensions: Length, 462 ft.; beam, 49 ft. 2 in.; depth, 33 ft. 6 in.; draught, 25 ft.; gross tonnage, 6,150 tons; displacement, 11,600 tons. She is built of steel, and is fitted with twin screws driven by triple-expansion engines of 3,500 horse power to give an estimated speed of 14 knots. Her classification at Lloyds is 100 A-1 (3 decks).

Previous to the construction of this vessel the largest vessels built in Japan were the Hashidate, a steel coast defense ship of 4,278 tons displacement and 5,400 I. H. P., carrying 30 guns of various calibers, with a speed of 17 1-2 knots, and the Akitsushima, a steel cruiser of 3,150 tons displacement and 8,516 I. H. P., carrying 19 guns. The Hashidate is a sister ship to two vessels built in France and the Hitachi is a sister ship to two for the same company built on the Clyde.

As might have been expected, such a notable advance was not achieved without encountering very great difficulties and incurring very considerable expense. In the first place, the greatest difficulty was found in assembling a sufficient staff of platers and riveters, who were recruited from almost every dockyard and boiler shop in the Kingdom, each gang being fully persuaded that its own peculiar methods were not only the best, but the only ones that could posssibly be adopted. The result was, of course, a large amount of wasted time, spoiled material, and defective work which had to be done over again. Miles of riveting had to be cut out and made good, and acres of defective plating replaced. In the first instance, Lloyds, acting on the report of two local surveyors, refused to rate her, and the Nippon Yusen Kaisha refused to accept her. Ultimately, after the whole of the defective work had been removed and replaced, they were requested to send over the best man they could possibly spare to make a fresh and independent survey. In the expert's report, addressed to Baron Iwasaki, president of the Mitsu Bishi Co., he said he found "the workmanship, including the riveting, satisfactory and equal in quality and efficiency to that done in good shipbuilding establishments in the United Kingdom."

Before undertaking the construction of the twin-screw vessel the Japanese company secured the

LAUNCHING OF THE FIRST LARGE MERCHANT STEAMER CONSTRUCTED AT NAGASAKI, JAPAN.

services of J. S. Clark, a naval architect, who was not only conversant with the best Scotch practice, but had also had considerable experience in surmounting the difficulties arising from half-trained labor and defective organization during some years professional engagement under the Spanish Government.

If the history of the new vessel from inception to launching could be written in full, it would afford a typical example of Japanese determination and independence. It would have been far cheaper and quicker to order the vessel complete and to enforce their authority and to insist that the rank and file should follow their directions implicitly; but they preferred to try their own experiments, and learn by experience cost what it might. Similar instances of this national trait may be continually observed. Foreigners in Japanese employment are becoming fewer in number each year, and the administrative powers intrusted to them are more and more curtailed.

The illustration herewith shows the Hitachi Maru just as she was taking the water, and incidentally gives a very fair idea of the picturesque harbor of Nagasaki.

The yard was laid out about 1860 by the Japanese Government under Dutch management, and was transferred to its present owners in 1884, since which time it has been rapidly extended. Iron shipbuilding was commenced in 1889. The concern now has two granite dry docks, respectively 523 ft. and 371 ft. long by 99 ft. and 66 ft. wide, with 27 ft. 6 in. and 24 ft. 6 in. over the sills at spring tide. There is also a patent slip with rails 750 ft. long and 30 ft. gauge and a lifting power of 1,200 tons, all of which are continuously occupied. The Hitachi Maru was launched without a hitch. The company employs about 3,500 hands and has taken another contract for a 6,000 ton vessel for the same owners. For these very interesting particulars and the engraving we are indebted to our contemporary the *Indian and Eastern Engineer* of Calcutta.

The Naval Board of Construction has recommended the sale of the old monitor Wyandotte. She is valued as worth about $7,000 as old iron. During the Spanish war she was in commission, manned by the Boston Naval Reserves.

The battleship Wisconsin was launched from the Union Iron Works, November 25. A delegation of visitors from Wisconsin was present and the vessel was christened by Miss Elizabeth Stephenson. This vessel is a sister ship to the Illinois and Alabama, both now under construction on the Atlantic coast. She is classed as a sea going coast line battleship, length, 368 ft. L. W. L.; extreme beam, 72 ft. 2 1-2 in.; mean draught, 23 ft. 6 in.; displacement, 11,525 tons. She will be propelled by twin screws, driven by vertical triple-expansion engines, and with 10,000 I. H. P. is expected to attain a speed of 16 knots. Her armament will include four 13-in. breech loading rifles; fourteen 6-in. rapid fire guns, and an extensive secondary battery, and also four long Whitehead torpedo tubes. The contract for her construction calls for her completion September 19, 1899.

DESCRIPTIONS OF THE STANDARD BOATS IN USE IN THE U. S. NAVY.*

BY ARTHUR B. CASSIDY, U.S.N.

The design of small boats for the Navy has been a problem which the naval constructors have been obliged to solve under circumstances somewhat similar to those affecting the designs of ships for the special purposes intended and under many conflicting and limiting conditions.

The necessities of special cases of boat design are illustrated by the dory of the New England fisherman, a light, handy craft of good freeboard and great carrying capacity. The average "banker" carries about a dozen dories, snugly nested by removal of the thwarts. Each boat is handled by two men and will carry in a draught of 12 ins. from 1,500 to 2,000 lbs.

The New Bedford whale-boat, famous for its speed, lightness and capacity, is an easy pulling boat with considerable sheer and sharp lines. The bow and stern are alike, so that the boat will work quickly in either direction, and there is considerable curvature in stem and stern post, so that it can be turned quickly by the boat steerer with his long steering oar and thus escape the fury of the whale. The boat is usually fitted with a small sail and center-board, carries a crew of seven or eight; five or six at the oars, a boat header and boat steerer, with all the necessary gear, harpoons, lances, tubs containing whale lines, etc. Each whaler usually carries about two spare boats, and in her complement of boats has more than enough capacity to easily carry all of the crew.

The surf boat is one with great sheer, full forward and after body, quick rise of keel forward and aft. A surf boat that has received great praise in the Navy is the Ranger boat, built at Mare Island, for use on the survey of the coast of Mexico and Central America.

The racing cutter or barge, built sharp and light as possible, is intended for racing in smooth water.

The light steam and naphtha launches, which are so popular along our coast in sheltered waters, are built as light as possible, and with their limited crew, serve their purpose admirably as pleasure craft in smooth water.

In each of the cases cited, the boat fulfils its purpose, but would be comparatively worthless if its use was attempted in any other class than that for which it was intended.

As in each of the above mentioned cases, so in the Navy, must the boats be designed for their specific purpose. They must be strong enough to stand rough usage in rough water. They must be stable under sail or oars, have great carrying capacity, and must be as light as is consistent with the necessary strength. The steam cutters must have the power and strength of construction to not only carry their own load of officers and men, ranging from sixty in the 40-ft. steam cutters to thirty-five in the 28-ft.,

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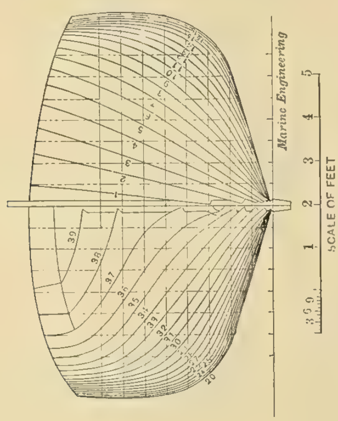
*A paper read at the Sixth General Meeting of the Society of Naval Architects and Marine Engineers, in New York.

but must be able to tow all the other boats of the vessel, loaded to their capacity.

As the usual space on naval vessels for the stowage of boats is limited, the number of boats that can be carried is also limited, so that in abandoning ship, when each man has his allotted place in a boat, there is not much spare room, as the boats, besides their human freight, must carry the requisite amount of provisions and water. Then, again, in landing parties, the men and equipments make a heavy load to carry, possibly through surf, to the shore, and with the banging upon the shore, require good, solid construction to stand the strain.

It is impossible to make the boats, in all their details, satisfactory to every one, but it is believed that the present types which have been adopted as the standard of the Navy more nearly fulfil all requirements and are more satisfactory to the majority of naval officers than any previous designs. These standard boats are not of an immediate growth, but are the result of experience of many years of actual service, and much time and thought by many men.

An order was issued by the Department April 1, 1870, relative to establishing uniformity in the size



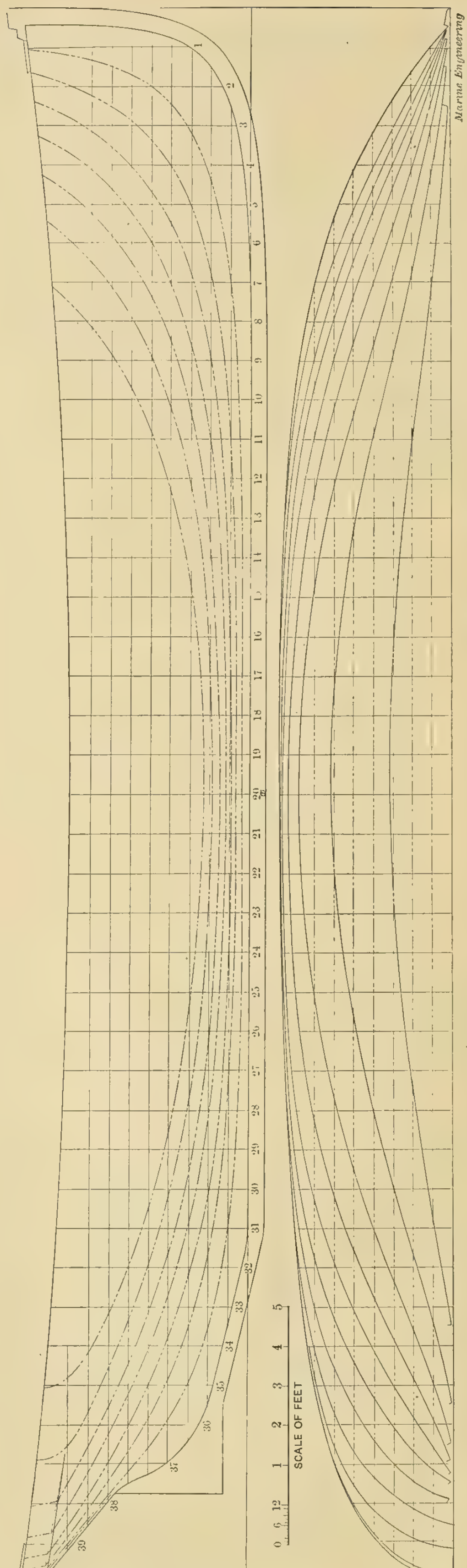
AFTER AND FORE BODY.

of boats. The vessels were classified, and a table prepared by John Lenthall, then Chief Constructor of the Navy, giving the size of boats that should be carried by each vessel, and also establishing the proportion of breadth and depth to the length, ranging from .282 of the length for breadth, and .4 of breadth for depth in launches, to .21 of the length for breadth and .39 of breadth for depth in whale boats.

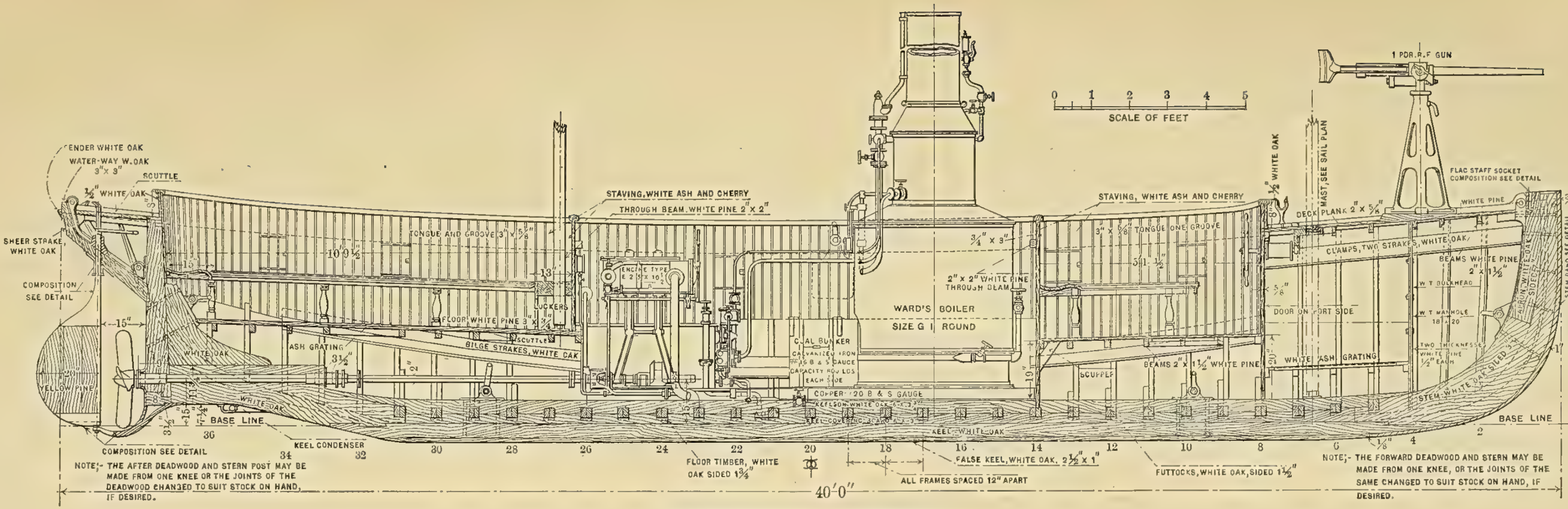
While this classified the boats as far as principal dimensions were concerned, there was no limit to the form of the boats, and in many cases the desire of the commanding officers, to have their boats faster than the boats of some other vessel, led to the construction of some tender boats entirely unfitted for naval use.

When it was determined by the present Chief Constructor to standardize the boats, the best boats in use were selected as the basis of the designs; the boats were studied for improvements, and the opinion of many officers afloat was sought.

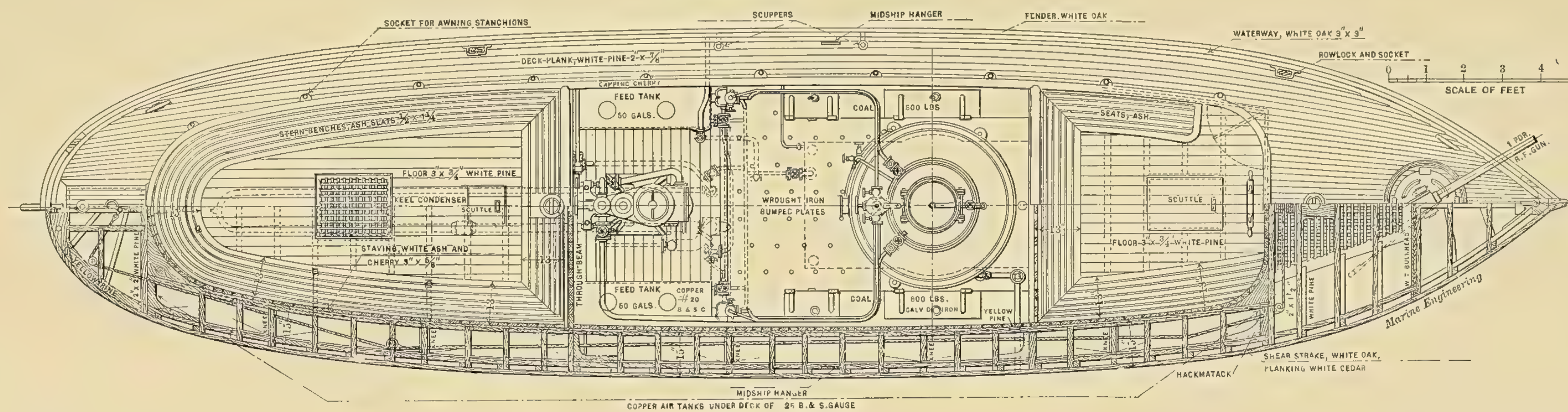
One point upon which all were united was, that the boats should have more carrying capacity. The principal difference of opinion was on the question of



LINES OF THE 40 FT. STANDARD STEAM CUTTER OF THE UNITED STATES NAVY.



LONGITUDINAL SECTION.



DECK PLAN.

GENERAL ARRANGEMENT OF THE 40 FT. STANDARD STEAM CUTTER OF THE UNITED STATES NAVY.

rig; about 75 per cent. of the officers were in favor of the sliding gunter; the remainder in favor of the standing lug.

In the compilation of the standard designs, the classes were first determined. The classes and principal dimensions are shown in the accompanying table: (Table I, Page 12.)

The essential qualities of a design for naval boats would be classed as follows: 1st, safety; 2d, weight; 3d, comfort; 4th, speed.

In order to secure the first element, safety, the boat must be of such form as to give stability, both under oars and sail. It must have strength to stand the strains of heavy weather, the rough usage which they sometimes receive when being hoisted and lowered, and must be able to stand considerable banging against the vessel, the wharf, or a float, and the shock of grounding on a beach, when landing with an expedition. The boats should have capacity

Principal Dimensions and Weight of Standard Boats of the United States Navy.

Type of Boat.	Principal Dimensions.			Weight. Pounds.	
	Length extreme.	Breadth extreme.	Depth* from top of gunwale to lower edge of rabbet.	Hull.	Total, including outfit.
Steam cutters	40'-0"	9'-0"	4'-7½"	8064	18642
	36'-0"	8'-9"	4'-6"	7148	15719
	33'-0"	8'-7"	4'-5"	5120	12768
	30'-0"	8'-0"	4'-2"	4763	10631
	28'-0"	7'-8"	4'-0⅞"	3692	8889
Launches	33'-0"	9'-3"	3' 8"	4359	6733
	30'-0"	8'-6"	3'-5"	2705	4769
	28'-0"	7'-5"	2'-8"	2150	3471
Cutters	30'-0"	8'-0"	2'-10"	2219	3384
	28'-0"	7'-5"	2'-8"	1872	2808
	26'-0"	6'-11"	2'-6"	1585	2460
	24'-0"	6'-6"	2'-6"	1100	1919
Barge	30'-0"	6'-11"	2'-8"	1712	2767
Whale-boats	30'-0"	6'-10"	2'-5"	1670	2537
	29'-0"	6'-8"	2'-5"	1463	2474
	28'-0"	6'-6"	2'-5"	1388	2344
	24'-0"	5'-11¼"	2'-2½"	1050	1781
Gig whale-boats	30'-0"	6'-2"	2'-5"	1375	2238
	28'-0"	6'-0"	2'-5"	1123	2014
Dinghies	20'-0"	5'-6"	2'-2"	700	1134
	18'-0"	5'-4"	2'-1"	516	950
	16'-0"	4'-6"	1'-10"	291	617
	14'-0"	4'-4"	1'-8"	236	537

* NOTE:—In case of Steam Cutters this heading should read—Depth from top of deck to lower edge of rabbet.

TABLE I.

to carry, in addition to their regular crew and stores, as large a number of men as possible, and they must have the form and a sufficient freeboard to be weatherly under sail in rough water, and to be able to carry as dry as possible her crew, the additional number of men allotted to the boat in abandoning ship, and provision and water for her complement.

Least Freeboard of Standard Boats of the United States Navy.

Type of Boat.		Maximum number of men boat will carry.	Weight of provisions and water.	Freeboard with maximum number of men and provisions.
Steam cutters	40'-0"	60	600 lbs.	1'-9¼"
	36'-0"	53	530 "	1'-9⅝"
	33'-0"	48	480 "	1'-9¼"
	30'-0"	40	400 "	1'-8⅝"
	28'-0"	35	350 "	1'-7⅞"
Launches	33'-0"	64	640 "	1'-10¼"
	30'-0"	50	500 "	1'-9¼"
	28'-0"	40	400 "	1'-1¼"
Cutters	30'-0"	45	450 "	1'-4"
	28'-0"	40	400 "	1'-2¼"
	26'-0"	30	300 "	1'-0"
	24'-0"	28	280 "	1'-0"
Barge	30'-0"	38	380 "	1'-0⅛"
Whale-boats	30'-0"	28	280 "	1'-1¾"
	29'-0"	25	250 "	1'-0⅜"
	28'-0"	22	220 "	1'-1⅜"
	24'-0"	18	180 "	—
Gig whale-boats	30'-0"	20	200 "	1'-2½"
	28'-0"	16	160 "	1'-2½"
Dinghies	20'-0"	12	120 "	1'-2¼"
	18'-0"	10	100 "	1'-0½"

TABLE II.

The capacity in men, weight of provision and water, and the freeboard as shown in Table II.

As the boats must be strong, and scantlings made as light as possible, careful workmanship is insisted upon, in order that all the parts of the boat may be properly joined together.

While it is not intended to encourage extravagance, it is insisted that every appointment shall be strong, neat, and symmetrical without regard to expense.

The practice is to have all frames made of white oak, steamed and bent. In many cases where these frames have been made from flitches, or the natural crook, they have not stood the strain of a sudden shock, have broken from the blast of a gun, or the swinging of the boat against the vessel or wharf.

The keels, stem, stem-posts, keelsons, frames, risings, footlings, and wash strakes are built of white oak, the plank of white cedar, the thwarts of white ash, and the boats are copper-fastened throughout. The hanging bolts are of galvanized iron, and are strongly riveted over washers or plates in the stem, keel, or stern-post. All metal fittings of the boats are of brass.

A change has recently been made in the stern benches, slatted seats being used in place of the flat bench, thus giving an easy shaped seat, similar to park benches, upon which a person can more easily sit when the boat is in motion, and also insure a comparatively dry seat at all times; it is also intended to replace the cumbersome cushions.

The barges and gigs are always finished in mahogany, the back-board being curved and carved with an appropriate design.

The whale-boats and gig whale-boats are fitted with copper tanks under the bow and stern sheets, and at the sides under the thwarts, to make them better life-boats.

The 30-ft. whale-boat has a tank capacity of 14 cu. ft. The steam cutters are also fitted with copper tanks; the 40-ft. steam cutter has, including a water-tight compartment at the bow, 62.3 cu. ft.

Of the fittings of the boats, the greatest difficulty has been with the detaching apparatus of life-boats. Many kinds have been used, and failures to work at the proper time have been noted. The automatic releasing hook is now being largely used in the Navy. By this appliance, the boat is under control from the deck, and is rapidly lowered, and automatically released as soon as the boat touches the water.

The second element of the designs is that ever present question demanding the constant attention of the naval architect—weight.

As previously stated, the scantling is reduced as much as is consistent with the necessary strength. The designs have been studied from three points of view—safety, strength and weight, and wherever it seemed possible to cut the weight, it was done.

In the systematic arrangement of the thwarts, the bow oarsman is located far enough aft not to be cramped in his movements, and also to give a large fore sheet for all necessary purposes.

The bows have a considerable flare to make them dry, and the lines are made as sharp as possible, keeping in view the capacity required.

Under the third element of the boat designs—comfort—might be specified the slatted seats in the stern sheets of all boats except launches and dinghies. It has been the aim in the standard designs to give the crew of the boat ample room for pulling, and the thwarts have been arranged both vertically and horizontally to that end.

The element last to be considered in the Navy boats is speed, and as the speed of a steam cutter is closely associated with the space and weight, any attempt at anything but moderate speed could not be considered in a Navy boat.

In rough waters, where the usual service of the boats would be performed, the speed ranges from 8 knots in the 40-ft. steam cutters to 6 knots in the 28-ft. cutters.

Many of the crews of the old Navy took a great deal of pride in their racing cutter, but in the new Navy, where everything has to be well considered from many points of view, the racing cutter seems out of place. As the boats are standardized, and those of all vessels are alike, size for size, a boat race would become a question of strength and endurance, and be much more interesting than a race between two boats of unequal form.

Under sail, the boats will not be speedy, as the sail power has been purposely kept low to keep down the size of spars, and the weight of sails and spars.

In the steam cutters, the sail area is 1.75 times the area of the load water line; in the launches, 3 times; in the cutters, whale-boats, and gig whale-boats, 2 1-2 times; and in the dinghies, 2 1-4 times.

The sail area of each boat is given in Table III printed on this page.

The life of the Navy boats is comparatively short, probably averaging 10 years.

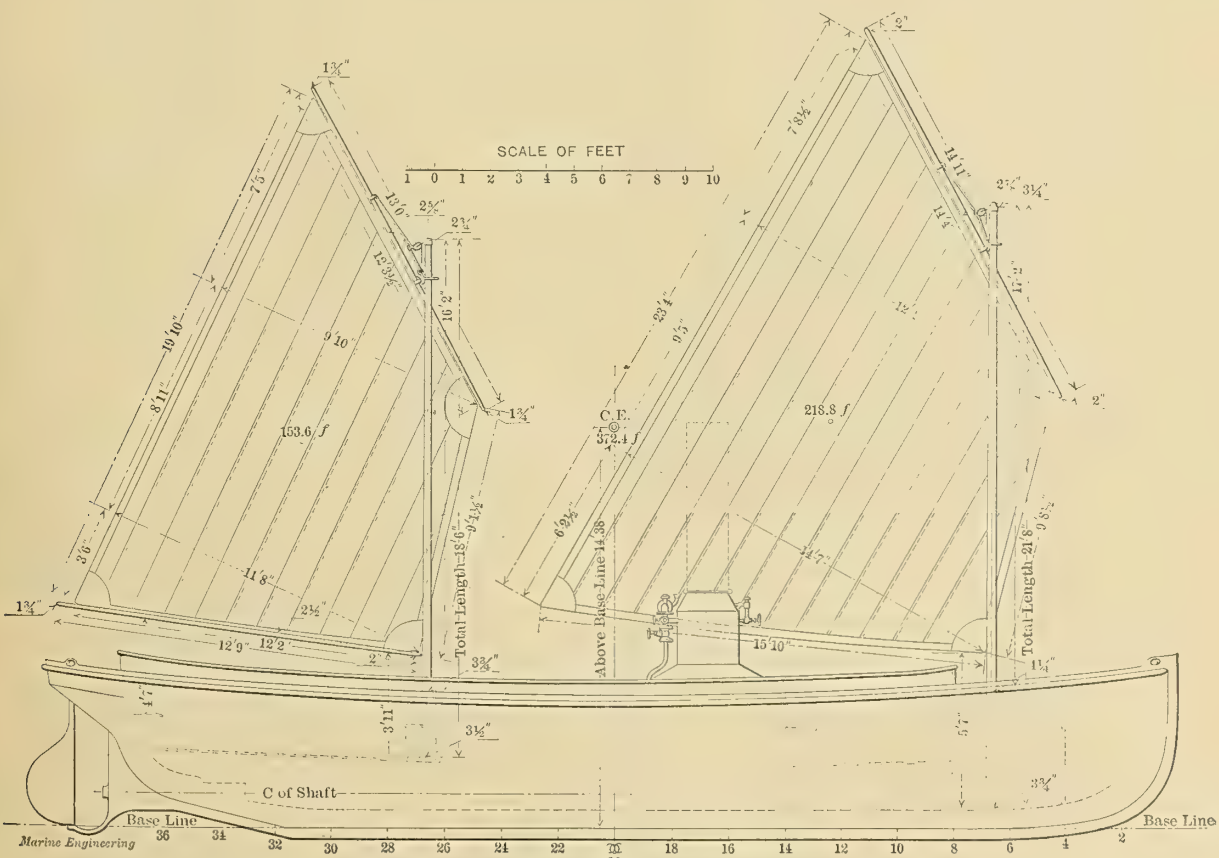
One hundred boats have been built during the past year, and there are now in use in the Navy about 1,000 boats of all classes.

Sail Areas of Standard Boats of the United States Navy.

Type of Boat.		Sail area.	Area of load water line.	Centre of effort from centre of length.	Centre of effort above base.
Steam cutters	40'-0"	372.4	212.8	on ⊗	14.38'
	36'-0"	318.58	182.0	.127' aft.	13.5'
	33'-0"	301.9	172.5	.046' "	13.46'
	30'-0"	283.75	145.0	.27' "	12.64'
	28'-0"	218.82	125.0	.207' "	11 77'
Launches	33'-0"	505.5	168.5	on ⊗	15.04'
	30'-0"	458.25	152.75	.298' aft.	13.9'
	28'-0"	290.0	—	.696' "	11 345'
Cutters	30'-0"	315.0	126.0	.773' "	12.0'
	28'-0"	290.0	114.75	.696' "	11.345'
	26'-0"	240.0	94.5	.685' "	10.647'
	24'-0"	209.0	—	on ⊗	9.79'
Barge	30'-0"	293.75	117.5	.41' aft.	10.7'
Whale-boats	30'-0"	287.75	111.5	.59' aft.	10.37'
	29'-0"	260.0	104.0	.52' "	10.29'
	28'-0"	240.0	96.0	.58' "	10.08'
	24'-0"	173.65	—	.198' "	9.55'
Gig whale-boats	30'-0"	236.8	94.75	.449' "	9.37'
	28'-0"	212.5	85.00	.238' "	9.43'
Dinghies	20'-0"	134.4	59.7	on ⊗	9.625'
	18'-0"	126.32	56.14	.354' aft.	9.67'

TABLE III.

The design of the standard steam cutter is shown in the engravings on pages 10, 11 and 13.



Note. No allowance has been made on plan for stretch of sails.

SAIL PLAN OF 40-FT. STANDARD NAVY STEAM CUTTER.

SLIP AND ITS RELATION TO THE PROBLEM OF SCREW PROPULSION.

BY EDMUND LEAVENWORTH.

Let us first try to understand why there is such a thing as *slip*.

The fundamental problem of propulsion is to obtain a thrust whereby the resistance of the ship may be overcome. Let us take first the case of a small boat propelled along a shallow stream by poling over a hard bottom. In such case there is no yield or give to the point of support. The necessary thrust is developed by simply pushing, and the point of support remaining firm, the boat alone yields and is thus urged in the direction desired. Under such circumstances there is an entire absence of the phenomenon of slip.

In the more usual case of propulsion, a like thrust must in some way be developed, but we have now no firm or unyielding support for the propelling agent, and the thrust must be obtained in an entirely different way. Let us see how this is done. It is a fact of universal experience that all bodies tend to maintain their condition of rest or relative motion. This is illustrated at every turn of our every day life. No body at rest can be put into motion, or if in motion can be brought to rest or can have its motion changed, except as it is acted on by a force external to itself. Again, since action and reaction are equal and opposite in direction, any body thus acted on will react on the disturbing agent, and thus produce the manifestation of a force equal and opposite to that required to produce the change. Thus suppose a heavy body hanging at rest by a rope. It requires to set it motion, the exercise of an external force, as the push of the hand, and a resistance is opposed to this motion, which reacts so that the pressure of the body on the hand exactly equals that of the hand on the body. Similarly the body, when once in motion, tends to continue in this condition and requires the manifestation of a force opposed to the motion in order to bring it to rest. It follows from this that if any agent on a ship can produce in matter an increase of motion directed in whole or in part in the direction from forward aft, such agent will be reacted on by a force directed in whole or in part from aft forward, and if the supply of such matter were continuous, such a force might be used as a propulsive thrust. It must be understood that these conditions will be fulfilled by the development of motion sternward in a body originally at rest, by the increase of motion sternward in a body already moving in that direction, or by a decrease, arrest, or reversal of motion in a body moving forward.

Thus a boy standing in a boat and throwing apples or stones over the stern, or a gun firing projectiles sternward, would each give rise to a forward propulsive thrust. Again, a boy in a boat catching apples or balls thrown him from astern would experience likewise a force directed forward, which would thus act as a propulsive thrust. Approaching a step nearer the actual case, we might have a pump on board drawing a continuous supply of water from overboard, and delivering it again overboard, with an accelerated velocity directed aft. In any and all of these cases, matter is so acted on that it is given motion or an increase of motion directed from forward aft, and the attendant reaction furnishes the necessary propulsive thrust. In the last case the plan is perfectly feasible for propulsive purposes, and such methods are occasionally used under the name of "hydraulic propulsion." In the actual propeller or paddle wheel precisely the same fundamental action occurs. In either case a mass of water is taken hold of and given motion sternward. With the screw propeller working at the stern of the ship in the wake, the water when first acted on has already a motion forward. This is arrested and reversed. In all cases, however, the fundamental action is the same, involving, as it does, the use of the *inertia* of the water, and the distinctive difference between gaining a propulsive thrust in this way and by poling over a hard bottom must be clearly noted. It may also be well to point out here more particularly, that it is the *change* brought about by the propeller which is of importance, and not the actual velocity itself. Thus, if the water were moving forward with a velocity of 4 and were stopped and turned backward with a final velocity of 2, the total change would be represented by 6, and the thrust developed would be the same as if the original velocity were 5 forward and final 1 aft, or 1 forward and 5 aft, or originally at rest and finally 6 aft.

It thus appears that the production of a propulsive thrust in this way absolutely requires a change in the sternward motion of the water. Such change is sometimes called the *slip* of the *water*. This, however, is not the slip with which we are here especially concerned, though it has been sometimes confused with it. This slip of the water, however, is accompanied necessarily by a slip of the propeller or paddle wheel; that is, by a difference in the performance of the propelling agent as compared with the case in which there should be no such yield or slip of the water.

Thus, in the case of a screw propeller, if there were no yield to the water considered as the support of the blades, and if the latter thus moved as though supported on a smooth, unyielding surface, the distance moved forward per revolution would equal the pitch as measured on the driving face of the propeller. In the actual case the distance moved per revolution is less than this, and the difference may naturally be called the *slip* of the *propeller*. That is, the propeller slip is the difference between the distance which the ship would move per revolution if the propeller worked on a smooth, unyielding surface, and the distance actually moved per revolution when it works on the yielding water. This is the slip with which we are here particularly concerned.

It should be carefully noted that the slip of the water and that of the propeller are quite distinct in character, and that they are furthermore not equal in amount. Their relationship involves mathematical investigation of a nature unsuited to the present discussion.

The facts thus far established are, therefore, (1) that no propulsive thrust can be developed without a yield or slip in the water, and (2) that this yield or slip will produce an effect on the relation between the geometrical or face pitch of the propeller and the distance moved per revolution.

We must now take another step and define two kinds of propeller slip. It has been defined above as the difference between the pitch of the driving face and the distance moved per revolution. The latter, however, admits of two definitions. The one naturally thought of is the distance relative to the outlying and surrounding body of *still water;* the speed of the ship through the water so called. Of still greater influence, however, on the propeller as an instrument of propulsion is the speed through the water which immediately surrounds it; the speed through the *wake* so called.

It may be well at this point to describe briefly the nature and constitution of the wake. The ship in going through the water sets in forward motion a skin of water, of which that very near the surface moves with nearly the velocity of the ship itself, while as the distance from the surface is increased, the motion correspondingly decreases. The water thus acted on by the skin of the ship is finally found at the stern, where, influenced still further by wave and stream-line motion, it forms the so-called "wake." The forward velocity in the wake at different points in a transverse plane at the stern is quite variable, rising as high as 50 or 75 per cent of that of the ship at points near the stern post at the surface, and decreasing irregularly and gradually to nothing as the outlying water is reached. For single screw ships the average value in that part of the wake directly influenced by the screw is usually found from 10 to 15 or 20 per cent of the speed of the ship. For twin screws, located as they are, not in the strongest part of the wake, the values are usually found between 6 and 10 per cent of the speed of the ship.

Now, to return to the propeller, it is evident that so far as it is concerned individually and simply as a developer of thrust, it should be judged relative to the water immediately about it—relative to the water in which it works and upon which it acts, rather than relative to an outlying body of undisturbed water upon which it has no direct influence. The velocity of the propeller through the wake and the corresponding slip are therefore more closely related to the performance of the propeller as such than the velocity relative to the surrounding still water and the slip corresponding to such velocity. The first is hence known as the *true slip,* while the second is called the *apparent slip.*

Suppose, for convenience, we reckon all velocities relative to the surrounding body of still water. Let u be the velocity of the ship and v that of the wake, reckoned, say, in feet per mt. Then $(u-v)$ is the speed of the propeller through the wake. Also if p denotes pitch in feet and N revolutions per minute, $p\ N$ would be the speed per minute if there were no slip. Then $p\ N - u$ is the apparent slip and $p\ N - (u - v)$ or $p\ N + v - u$ is the true slip. Denote these two slips expressed in feet per minute by S_2 and S_1, respectively. Then we have:

$$S_1 = pN - u \quad \text{(1)}$$
$$S_2 = pN + v - u = S_1 + v \quad \text{(2)}$$

It thus appears that the difference between the two slips is simply the wake velocity, as we should expect. It is customary to reduce S_1 and S_2 to percentages of $p\ N$ as a base, and to speak more particularly of these values as slip ratios or slip per cents. Denoting these by s_1 and s_2 we have:

$$s_1 = \frac{p\,N - u}{p\,N} \quad \text{(3)}$$

$$s_2 = \frac{p\,N + v - u}{p\,N} = s_1 + \frac{v}{p\,N} \quad \text{(4)}$$

Very commonly when slip is referred to, apparent slip is intended; though in scientific discussion of screw propulsion, true slip will be more commonly implied. In any case the context will show which of the two is intended, and the fact of the two different kinds, the cause of their difference and their relation should be borne constantly in mind.

We have thus far considered slip as though it were the same for all parts of the blade and for all parts of the revolution. Such, however, is far from being the case. Due to the lack of uniformity in the constitution of the wake, different parts of the blade at any one instant are located in water having different velocities, and any one part of a blade during a revolution is in contact with water having likewise widely differing initial velocities. In consequence, the true slip in any given position of a blade varies from one point to another, while at any given point on the blade it varies during a revolution. Nor are these variations so small that, as is so often the case, we may fairly consider them negligible. From the best information obtainable on the subject, the true slip may vary in this way at different points on the blade and at different parts of a revolution from little or nothing up to 50 or 75 per cent, or, perhaps, even more. It is true that for the most part the slip varies through narrower ranges, but, nevertheless, the variation is very considerable, and in any case is sufficient to entirely destroy the simplicity of meaning which we may attach to the idea of slip in the case of a propeller working in a uniform or undisturbed stream of water.

But there is still another cause which may introduce variability into the slip. This is a variability in the pitch. It is well known that in many propellers the pitch varies from one part of the blade to another in a manner more or less complex according to the *fancy* of the designer. Remembering the way in which pitch is defined, it follows that slip will vary correspondingly, even if the water in which the propeller works is perfectly undisturbed. In all cases where pitch and slip are variable, these terms for the propeller as a whole must be understood as referring to a kind of mean value. We are therefore called upon to define *mean pitch* and *mean slip.* This may be done in several ways according to the manner in which the mean is taken and unfortunately there is no generally accepted agreement on this point. Following are some of the ways in which the mean pitch might be defined:

(a) Taking a purely geometrical basis, mean pitch may be defined as the simple mean of a set of distributed values taken over the driving face.

(b) Instead of a simple mean we might perhaps more properly give to the pitch of each element a weight proportional to the work which it absorbs, or to the thrust which it develops. The latter, which is perhaps preferable, may be approximately accomplished by dividing the blade area into a series of elements and multiplying the area of each element by its pitch and by the square of its radius, adding these products, and dividing the sum by the sum of the like products formed by multiplying the area of each element by the square of its radius.

(c) We might also adopt a dynamical basis for the definition of mean pitch as follows: Let the given propeller work in undisturbed water with given revolutions and speed of advance. Let there be a propeller of uniform pitch with the same diameter, area, and shape of blades, and let it work in undisturbed water at the same revolutions and speed. Then the pitch at which the latter propeller would have the same turning moment, or in other words, at which it would absorb the same *work* as the former, may be considered as the equivalent mean pitch. Still otherwise the pitch at which the latter would develop the same *thrust* as the former may be considered as the equivalent mean pitch.

(*To be continued.*)

The ocean going steam yacht Aphrodite, built by the Bath Iron Works for Colonel Oliver H. Payne, of New York, was launched on the Kennebec river, December 1. She was christened by Miss Vivian Scott, daughter of Captain C. W. Scott, who will command the yacht. Our readers will recollect the extensive description, with drawings, of this vessel which we published in our issue of February, 1898. Her dimensions are: Length, 258 ft. L. W. L.; beam, 35 ft. 6 in.; mean draught, 15 ft. She is fitted with a single screw and engines of about 3,000 I. H. P. Her equipment and appointment will be of the very latest and most artistic design.

The hull of the new steam yacht Corsair for J. P. Morgan, of New York, was launched from the yard of T. S. Marvel & Co. at Newburg on the Hudson, last month. She was christened by Miss Louise Morgan, daughter of the owner. This vessel was designed by J. Beavor Webb, and will be fitted with her machinery at the yard of W. & A. Fletcher Co., Hoboken, N. J. The new yacht is 302 ft. long, 33 ft. 3 in. beam, and 23 ft. 6 in. deep. She will be fitted with triple-expansion engines and is expected to be a speedy, seaworthy vessel. The yacht of the same name previously owned by Mr. Morgan was purchased by the Navy Department during the Spanish war, and contributed greatly to the success of the naval fight at Santiago. This vessel was illustrated and described in our issue of August, 1898.

ELECTRICALLY OPERATED 150-TON JIB CRANE AT NEWPORT NEWS SHIPYARD.*

BY WALTER A. POST.

Together with the demands of the day for greater capacity, greater power, and greater speed, as essential characteristics of the modern ship, there comes the dependent feature of greater weight, and, to the shipbuilder, the problem attendant upon this feature, namely, that of providing for the economical handling of these weights.

The plant of the Newport News Shipbuilding and Dry Dock Co., although well provided from its origin with appliances for handling material, was found in its later developments to be in need of apparatus more powerful and more convenient than the 100-ton sheer legs which, to that time, had been used for handling the heavier weights installed on board ships during the fitting-out period.

The growing need of such apparatus had been for some time forcing itself upon the attention of the company, but it was only in the spring of 1896 that it was finally determined to undertake its provision, and steps were taken to ascertain from the experience and opinions of experts, both in this country and abroad, what general type of machine would most satisfactorily fill the particular requirements of the Newport News plant.

The fundamental requirements, briefly stated, were: Capacity to lift and place on board the heaviest single weight liable to be incurred in the probable development of modern ships; a field of operation, as large as practicable, in which these weights could be handled, and absolute precision within this field; a location accessible by the ordinary means of transportation from all parts of the yard; and, finally, that greatest factor defined in all projects by the broadest use of the word economy.

Careful consideration of these requirements lead to the adoption of a 150-ton revolving derrick, electrically operated and controlled, mounted on a steel tower supported in turn by pile foundations. The structure was located on one side of a pier 700 ft. long, forming one side of a slip, in which a number of ships may be moored at one time and readily brought within the field of the derrick's operation. Two standard gauge tracks over entire length of pier afford means of transportation from any part of the yard, and also direct connection to the main lines of the Chesapeake & Ohio R. R. System. The floor of the pier, 185 ft. in width, furnishes ample room for the temporary reception of heavy pieces, castings, armor, etc., and permits, in addition, the assembling of much work within direct reach of the derrick, thus allowing assembled parts to be placed on board as a single member, relieving the tendency to overcrowd floor space in the shops and effect a saving in cost over work as assembled on board ship.

The final design of the derrick was taken up about March 1, 1897, and in July, 1898, sixteen months

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*Read at the Sixth General Meeting of the Society of Naval Architects and Marine Engineers.

150 TON ELECTRICALLY OPERATED JIB CRANE AT NEWPORT NEWS SHIPYARD.

later, weights were being placed on board the battleships in course of construction at the yard.

Aside from the steel work in the tower, it was designed, constructed, and erected by the Newport News Shipbuilding and Dry Dock Co., under the direction of Sommers N. Smith, at that time general superintendent of the works. The design of the derrick itself, including steel tower, jib, hoists, and machinery in general, was prepared by the steam engineering department under C. F. Bailey; the direct working out of plans and details being assigned to R. L. Lovell of the same department. The successful completion and high efficiency of the whole machine attested both the care and skill of the designers and the workmanship of the yard force. The steel tower was furnished and erected by the Berlin Iron Bridge Co., of East Berlin, Conn.; while the foundations were designed and constructed under the direction of the author.

A brief statement as to size, capacity, range of operation, etc., may be of interest before proceeding to the description of particular details.

The derrick jib is capable of having its outer end raised or lowered, thus giving to the hoisting blocks, which depend vertically from this end, a movement not only of rotation about the center of the derrick, but also of translation in or out from this center. With the outer end of the jib in its lowest position the hoisting blocks will, on rotation of the derrick, describe the circumference of a circle 207 ft. dia.; with the jib in its highest position these blocks, on rotation, describe the circumference of another concentric circle 88 ft. in dia., thus permitting the derrick to operate on weights lying anywhere within the circle ring whose maximum and minimum diameters are 207 ft. and 88 ft. respectively. The maximum load of 150 tons can be handled only within a ring whose maximum and minimum diameters are 147 ft. and 88 ft. respectively, but weights up to 70 tons may be handled throughout the entire field of operation. This feature, of varying the radii at which the hoisting blocks can operate, constitutes a most important difference between the derrick under discussion and the 130-ton steam crane erected, in 1893, on Finnieston Quay, Glasgow. In the Finnieston crane, which at the time of its construction represented the ideas of best English practice, there is no variation in the radius at which the hoisting blocks are carried, and, in consequence, the field of operation becomes narrowed to a single line, the circumference of a circle described by the blocks on revolving the crane. The advantages of the Newport News derrick are obvious.

The maximum elevations, above mean high water, for the hoisting hooks in the high and lower positions of the jib are 118 and 69 ft. respectively; this giving ample clearance vertically for any probable conditions.

Taking up the description of the several parts of the structure, it may be well to follow the actual order of construction and begin with the foundations.

A discussion of the conditions which serve to determine the choice between a masonry or pile foundation is obviously beyond the scope of the present paper, and it is sufficient to say that the decision to adopt a pile foundation was reached, not alone after the possibilities of masonry, but also of metal tubes and cylinders filled with cement, had been investigated at much length. The soil at the point of erection is eminently suited to the use of piles, and it is the author's belief, based on a number of years' experience in that locality, that a properly creosoted pile foundation would, under conditions imposed, have about 90 per cent. of its original strength retained after a period of 25 years. Assuming the probable life of the foundation to be 25 years, and recurring again to the governing factor of economy, we may, with pertinence, state that the cost of such foundation was about $8,000; and the time consumed in construction about two months; while the masonry foundation for the Finnieston Quay 130-ton crane cost in the neighborhood of $45,000, and required seventeen months to complete. It is apparent that the interest accumulations on the difference in cost for a period of 25 years is far more than sufficient to renew foundations and re-erect derrick.

The foundations adopted consist of four concentric rows of piles, driven vertically and spaced 3 ft. center to center, measured on the circumference of each ring. One hundred and fifty piles were required for these rings, all carefully selected straight round sticks, measuring not less than 14 in. 6 ft. from the butt, and not less than 9 in. at the small end. They were carefully treated with London ordinary dead oil, of approved quality, 16 lbs. to the cubic foot, and then driven, under a 5,000-lb. hammer, to an average depth of 28 ft. into the hard bottom of the river. In addition to the above, seventy piles were driven at an angle of 30 deg. to the vertical and secured to the capping by galvanized iron drift bolts, thus giving the entire foundation greater rigidity and stability. The caps are carefully selected live oak, 14 in. by 11 in., laid in concentric circles on tops of piles, surmounted in turn by two thicknesses of heavy live-oak flooring, the lower flooring being laid radially across the caps, while the upper one has its lengths laid, similarly to the caps, along the circumferences of concentric circles. The whole assemblage, of caps and flooring, is protected as much as possible from decay, and firmly secured to the piling by galvanized iron drift bolts. It may be well to state, as a concluding remark on the pile foundations, that it is intended to fill the pier solidly around the space occupied by the derrick foundations, thus preserving the piling for an indefinite period from possible attacks of the teredo.

Proceeding to the description of the steel tower:—we have a structure cylindrical in general form, comprised of sixteen columns securely braced and anchored, through their shoe plates, to the pile foundations below, the columns being surmounted by a series of box girders to which is bolted the cast-steel track carrying the rollers on which the derrick revolves. The sixteen columns are equally spaced over the circumference of a circle 36 ft. dia. and set square to radial lines through their centers. They are built up of two 15-in. channels, 70 lbs. to the foot, well latticed on the sides, with batten plates, top, bottom, and midway their height, at which point horizontal and diagonal braces connect. The column shoe plates are seated on iron plates 1 7-16 in. thick, carried by the upper course of live-oak flooring, each shoe being anchored by twelve 1 3-8 in. bolts to the piles, if possible, and where not, to the pile caps.

To heavy box girders, surmounting the columns, are riveted at every other column the ends of lattice girders projecting radially from the center, at which point they connect to heavy gusset plates which serve to build up a central bearing for the 16-in. vertical pin used to center the derrick, and which serves, also, should unforeseen emergency require it, to prevent any lifting tendency of the derrick itself. Projecting outward and downward from the pin bearing, to the base of each alternate column above mentioned, are stiff angle braces, tied at their middle points to the top and middle point of columns by diagonal and horizontal angles. Diagonal tie rods, 2 in. dia., running from the top and bottom of the alternate columns, which do not carry radial girders, to the bottom and top of corresponding columns opposite, serve, with the above-mentioned angle braces, to rigidly connect and tie together the whole structure of the tower. The circular turned cast-steel track, on which sixty-three conical cast-steel rollers travel, has a mean diameter of 36 ft. for the roller circle and is so beveled that the top elements of the rollers are always horizontal, thus ensuring an easy turning motion. The rollers are held in place by two concentric circular rings, the inner one built up of plates and angle bulb, the outer one of plates alone; these rings being held in place by twenty-one 2-in. steel rods, radiating from the center pin casting, to which they are secured, and passing axially through every third roller and secured at the same time to both roller rings.

We have now reached the revolving structure or derrick proper, which may be, for convenience of description, divided into two members; the housing, a heavily framed structure containing the generating and controlling machinery, operating platform, and counterweight or ballast; to this is secured the second member, namely, the jib, which, carried by the housing and controlled by the power therein, carries in turn the sheaves and blocks through which all the hoisting power must be finally applied.

Recurring to the housing, a brief description will suffice to indicate its general character and note interesting features.

Resting on the conical rollers is a circular girder; on this is carried the heavy cross-girders which furnish supports and foundations for the generating motors, heavy gearing, drums, and other parts of machinery. In a central bearing is the 16-in. pin previously mentioned; at one end of the cross-girders is secured, by a 9-in. pin connection, the lower end of the jib, while at the opposite end of the girders rises the ballast tank containing 410 tons of pig-iron ballast. The ballast tank is built up of heavy floor girders, resting on and running at right angles to the cross-girders above mentioned. From the extremities of these floor girders rise the vertical ends of the tank, each end being a hollow box section and serving to transmit the weight of the ballast from the floor of the tank to the 10-in. pin connections at the top of the tank, from which points inclined struts are run downward and across to the ends of the cross-girders which connect with the lower end of jib. The ballast tank overhangs the circular girder, and as only a portion of the weight of the ballast is required to balance the jib in its high position, the remaining weight of ballast is carried, in that case, by the overhanging girders, which are reinforced by brackets on the side. The arrangement of ballast above described brings the center of gravity of the revolving structure always within a radius of 7 1-2 ft. from the center, which, as the path of the roller bearings has a mean radius of 18 ft., gives a minimum factor of stability of 2.4. Thus, with the jib in its highest position and no load, the c. g. is 7 1-2 ft. behind the center, while with 150 tons load at 73 1-2 ft. radius, or 70 tons load at 103 1-2 ft. radius, the c. g. is 7 1-2 ft. forward of the center. As before referred to, the 16-in. central pin is provided with a top nut and secured below, which thus affords a further safeguard against tilting.

Turning, for a moment, to the jib, attention may be called to the endeavor to so arrange sheaves as to bring the minimum amount of bending and wear upon the pins. The member as a whole is a triangular truss, pin connected and with its long side in compression.

In taking up now the operation of the derrick we will divide our remarks into three headings, corresponding to the three main movements, namely, revolution, elevation or depression of the jib, and the vertical movement of the hoists.

The derrick is revolved by duplicate sets of machinery, each consisting of one No. 800 General Electric railway motor, capable of developing 20 H. P., and driving, through means of a double threaded worm and wheel of the Albro-Hindley pattern, a pinion which, engaging a horizontal circular rack on the outside of the tower, gives the required movement of rotation. The motors are series wound and controlled from a series parallel controller, giving high efficiency under starting conditions as well as at normal speed. The turning motion is very smooth and perfectly noiseless, and, as will be seen from the tests, requires very little power.

The racking movement of the jib is effected as follows: At the inner and upper apex of the jib is a 10-in. steel pin carrying twenty-two cast steel sheaves, each sheave of 5 ft. pitch dia. At the upper apex of the housing is another 10-in. steel pin carrying twenty-four similar sheaves. Leading over these two sets of sheaves, and sustaining the weight of the jib and load, are two 1 1-4-in. steel wire ropes; each rope being wound on alternate sheaves and each end of each rope brought down to separate drums, located below in the housing; this arrangement ensuring freedom from side twisting on the sheaves and also requiring each rope to take its share of the weight. The four drums, on which these ropes are wound, are arranged in pairs, each one of a pair taking opposite ends of the same rope and each pair driven by a No. 2000 General Electric series motor of 100 H. P.; the power from the motor being transmitted to each drum through a separate train of gears. The drums are of cast iron, 5 ft. pitch dia., carried by 7-in. steel shafts. Each rope, having twenty-two parts, is strong enough to sustain and operate the jib when under maximum load, thus guarding against accident and enabling either motor to be disconnected, and the rope, which it controls, to be removed for repairs or renewal. The motors are series wound, which ensures each taking its proper share of the load.

Passing finally to the hoist, we have two main hoists, each of 75 tons capacity, and one 20-ton whip for lighter loads. The main hoists are each of 12 parts, 1 1-4 in. steel wire rope, leading over six sheaves, 5 ft. pitch dia., carried on a 10-in. steel pin at the outer end of the jib. The lead from these sheaves to the operating drum is carried down the jib on wooden roller runners. These drums, one for each hoist, are of cast iron, 8 1-2 ft. pitch dia., carried on 7-in. steel shafts, and each driven through a train of gears, by a No. 2000 General Electric 100 H. P. motor, series wound. These hoists may be coupled together and operated as one hoist of 150 tons capacity. The 20-ton whip is of three parts, 1 1-4 in. steel wire rope, carrying a single block and leading over two sheaves, carried, as are those for the main hoist, at the outer end of jib. The lead from these sheaves passes down the jib, over a single guide sheave, to a cast iron drum, 8 1-2 ft. pitch dia., driven through a train of gears by a No. 2000 General Electric 100 H. P. motor, series wound.

It will be noticed that electricity is used to generate the power required for all the movements of the derrick. The question involved in the choice as to the form of energy to be employed in such a machine cannot be fully discussed here, but the convenience of operation, ease of movement, and general efficiency of the present derrick attest the successful use of electricity in this case. Current is transmitted, over heavy insulated copper wire, to fixed brushes, attached at the center and near the top of the steel tower. These brushes are arranged to bear against circular contact rings insulated from, but carried by, the center casting to which the roller rods are secured. Near the top of this casting are two more contact rings which transmit the current to a pair of brushes, fixed to the revolving part of the derrick, from which the current is delivered over heavy insulated copper wire to the several motors. The current is delivered to the motors, under normal conditions, at a pressure of 220 volts.

Before concluding, it may be interesting to note a few particular features, and to give the result of such tests as opportunity has permitted up to the present time.

The brakes are a feature of considerable interest. These were required to occupy little space, be powerful and certain in their action, and to be automatic. This was accomplished by extending the ordinary band brake so that it wound four and one-half times around a brake cylinder carried on the shaft to which is keyed the pinion that meshes into the gear of the operating drum. This brings the brake in as direct connection with the load as possible and guards against accidents of the machinery. The brake cylinders are of cast iron, 30 in. dia., with the wearing surface chilled. The band is of wrought iron 1 in. thick, 5 in. wide at one end, and tapering to 1 1-4 in. at the other. The broad end is firmly anchored, while the narrow end is secured to a lever carrying a weight of 200 lbs. When lowering the jib or the hoisting blocks, the direction of rotation for the brake cylinders is toward the small end of the band, so that the friction, produced by the weight, between the cylinder and band, causes the band to wind tight on the cylinder and stop rotation. In hoisting, the brake releases itself, the friction lifting the weight and uncoiling the band; while any tendency to rotate in the opposite direction causes the weight to fall and the band to tighten. To release the brake it is only necessary to lift the weight, which is done by means of a wire connecting with a lever in the operating house; the lever being always within reach of the operator and the brakes always in operation except as released by continuous pull on the lever.

The operating station is directly underneath the lower end of the jib, overlooking directly the weights to be handled, and encased with glass front as a protection against the weather. The controllers for the several motors are within easy reach of a single operator, who is thus given convenient and absolute control over the varied movements of the derrick. The ropes for the hoist and racking movement are all of plough steel wire, 1 1-4 in. dia., of six strands of thirty-seven wires each, with hemp center and very flexible. Each rope has a breaking strength of 100,000 lbs. The gears throughout, except the worms and those supplied with the motors, are of cast steel with cast teeth, the pinions being full shrouded. These gears work very smoothly and show a high efficiency.

The difference in power required for the two main hoists is explained by the fact that all gears, except the pair on motors, have cast teeth and, consequently, variable friction. All tests were made soon after the completion of the derrick, and still better results may be anticipated when opportunity has been given for the gears to wear smooth.

The jib has been both raised and lowered with loads up to 66 tons, but, as this was done only in regular course of work, no data was taken. In hoisting, the required power decreases as the moment of the jib decreases. In lowering, power is required to start the machinery, after which the weight of the jib will keep it in motion.

The variation in speed and power required was probably due to influence of the wind, as the observations were taken on different days, with different velocities of the wind. Tests Nos. 3 and 4, taken as near as possible, show no difference in result, although the position of the center of gravity varied considerably.

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The safety factors attained in the various members are as follows:

For the jib:

Members.	Factors.
Lower struts or legs	10
Tension members—eye bars	9
Inclined struts	7
Wind bracing	12

In hoisting ropes	7
In tower columns	7.5
In tower wind bracing	15

The total weights in long tons are as follows:

Derrick on rollers (no load)	775
Derrick on rollers (maximum load	925
Entire structure on piles (no load)	926
Entire structure on piles (maximum load)	1076
Maximum load for piles, taking vertical piles only and considering eccentricity of loading	9.04

Following is a brief summary of tests:

REMARKS ON THE INDICATOR AS APPLIED TO THE MARINE ENGINE.*

BY W. S. BAILEY.

For the indicator we are indebted to James Watt; and like other of his inventions, such as the governor and the separate condenser, the indicator of to-day, although improved in detail and manufacture, is similar in principle to that used by its inventor. Watt's first indicator consisted of a cylinder about six inches long and an inch in diameter fitted with a tubular piston whose motion was balanced by weights; these weights, however, were soon replaced by a spiral spring as in more recent instruments. At first the surface, a paper-covered board, upon which the pencil acted, was fixed so that the diagram obtained was simply a vertical line whose extremities showed the pressure in the cylinder at each end of the stroke. But, subsequently, the paper-covered board was made to slide in grooves to and fro before the pencil with a motion proportio_al to that of the engine piston, movement being obtained by a cord attached to some suitable part of the engine, and the sliding board being balanced by a suspended weight. This automatic movement of the board was a great stride forward, because a diagram could now be traced whose length was proportional to the engine's

Tests of the 150 Ton Electrically Operated Jib Crane at Newport News Shipyard.

MOVING JIB.

Movement.	Net load.	H. P.	Time.
From lowest to highest position	0	89.0 to 64.1	6.9 min.
From highest to lowest position	0	0. 0.	5.56 "

HOISTS.

Hoist.	Net load, long tons.	Speed in ft. per min.	H. P. delivered to motor.	H. P. required to hoist load.	H. P. absorbed by mach'y.	Efficiency.
Right-hand main	68	6.05	54.3	28.0	26.3	51.5%
"	0	10.12	29.2	0.	29.2	0.
Left-hand main	66	7.03	61.9	31.4	30.5	50.9%
"	0	9.08	30.65	0.	30.65	0.
Whip	19.2	52.3	88.9	68.3	20.6	76.8%
"	0	84.3	35.35	0.	35.35	0.

REVOLUTION.

No. test.	Net load, long tons.	Total weight on rollers.	C. of G. from center of revolution.	Time of one revolution.	H.P. delivered to motors.
1	134	910	4.28 ft.	3.38 mins.	10.71
2	68	845	2.22 "	3.36 "	11.17
3	0	775	1.47 "	3.04 "	11.15
4	0	775	7.00 "	3.04 "	11.15
5	0	775	4.49 "	3.55 "	10.65

In concluding this paper it may be said that the most difficult problem encountered, in the design of the derrick, was that of providing a safe and efficient way of operating the jib, and, in so far as the author knows, the method adopted is, considering the large forces involved, something of a novelty. The results attained and the efficiency of the mechanism would indicate that the problem had been well solved, and that the idea here carried out might, with advantage, be extended by other designers to future problems.

stroke and whose height at every part corresponded to the pressure in the cylinder at that part of the stroke. The presssure on either side of the piston was also shown, with the cut-off, expansion and compression of the steam. The mean pressure throughout the stroke could be calculated; and, from this, the work done by the engine and the proportion of that work to the coal burned.

Watt had, therefore, in his indicator a miniature

*Paper read before the Institution of Engineers and Shipbuilder of Hong Kong.

engine, which showed him graphically the action of the steam within the main cylinder; and crude and imperfect as was the appliance, it greatly assisted him in improving the working of his engines and in illustrating his doctrine of the expansion of steam by enabling him to show that more work could be got from a given amount of steam by expansive working. With higher working pressures and increased piston speeds, the momentum of the indicator's moving parts interfered seriously with the accuracy of the diagrams. Lighter parts and shorter stroke of indicator piston were therefore called for; and with these improvements the name of M'Naught of compound engine fame is identified. M'Naught improved the indicator by increasing the pencil movement through a lever; and to attain a straight line vertical motion of the pencil he adopted in its movement a parallel motion. The principle of securing a wide range of pencil travel with a short piston stroke is maintained in all modern indicators, and is perhaps the greatest improvement ever made in the instrument. The parallel motion, in some form or other, is also maintained to the present day.

With the extensive application of compound engines the indicator came into more general use, that bearing the name of Richards being almost universal in marine practice for many years. This instrument, by Charles B. Richards, may be said to mark an era in the history of the indicator; for being far ahead, both in design and manufacture, of any that had yet appeared, it was extensively adopted. The value of the indicator in estimating horse power for commercial and scientific purposes and by revealing faulty valve settings and other defects became so well appreciated that it seldom was absent on a trial trip of any importance.

The Richards indicator is so familiar as to require little description. The card is secured by clips to a revolving brass drum. The increase of pencil stroke over piston stroke is attained by two pairs of levers pivoted at opposite ends, and connected by a pair of links to whose center is attached the pencil, and near whose inner end is connected the piston rod. The piston of the indicator is exactly one-half of a square inch in area, and its travel is multiplied four times, so that the diagram is four times as high as it would be if the pencil was attached directly to the piston rod. But, with still increasing pressures and piston speeds, the number and weight of the moving parts of Richards' indicator told against it; and it was followed, and to some extent displaced, by the Thompson. In the Thompson indicator the pencil receives motion through a single bar and a simpler arrangement of connecting links, so that the weight and therefore the momentum of the pencil movement is less, and more accurate results are obtained.

The Tabor indicator, following upon the Thompson, represents the best practice of the present day, and may be taken as illustrative of the numerous class of first rate instruments, such as the Crosby and the M'Innes, which compete for our approval, and which show the advances made upon the indicator of Watt. In the Tabor indicator the pencil moves five times as fast as the indicator piston, and a vertical straight line motion of the pencil is obtained by a simple and ingenious device—an upright slotted link on the cylinder cover of the indicator engaging a pin upon the pencil bar. The cylinder cover with its attachments is secured to a separate and outer cylinder, so that the main or internal cylinder, in which the indicator piston works, is less liable to distortion. The springs are duplex, being made of two spiral coils fitted with their points of connection to the caps opposite each other.

Speaking of springs, and as showing the importance of their mode of attachment to the caps, it may be mentioned that in the early days of the Richards indicator, in 1869, the springs (single coil), while correct at one pressure, were found inaccurate at another. Investigation by the makers showed the trouble to be due to the method of securing the springs to the end nuts, the springs being secured at their ends by half a turn, so that the spring was stiffer than it should be, and failed to respond readily to increase of pressure, while, on sudden release from pressure, the reaction of the spring was greater than it should be. Upon the discovery of this error, the springs already issued were recalled and replaced by the makers with correct springs, whose coils were secured to the end nuts by their points only.

Among details of improvement in modern indicators may be noted the small check, or stop, for regulating the pressure of the pencil upon the paper, an important point, both as regards accuracy of the diagrams and quickness and convenience in taking them.

The indicator is not perfect in its action from the fact that, on the one hand, the parts have weight and therefore momentum, which tends to make the diagram larger than it should be, and on the other hand, friction, which tends to make the diagram smaller than it should be. The early Richards, for example, contains also a radical defect in the multiplying movement, the pencil not moving through equal parts of its stroke, while the indicator piston moves through equal parts of its stroke. This is due to the angularity of the link connecting the piston rod to the pencil levers, and which acts in the same way as the connecting rod of an engine in relation to its crosshead; as the pencil is raised or lowered from a horizontal position its travel decreases in proportion to the travel of the indicator piston. In the best instruments this defect has now been greatly modified or entirely overcome; and, although the errors inseparable from momentum and friction cannot be entirely eliminated, they are small, certainly much smaller than other sources of error which will now be considered; and for all practical purposes the indicator is reliable.

Before applying the indicator, it is necessary to use some kind of reducing motion by which the card may be moved through a distance of only a few inches while the engine piston performs its stroke. In marine practice the commonest method of effecting this is by a lever worked from the engine crosshead and pivoted at or near its outer end, the cord being attached to some intermediate point in the lever. The various forms of reducing motion require no detailed description here, but the lever system of reducing motion contains a serious defect, which is illustrated in Fig. I. The diagram is shown divided into ten

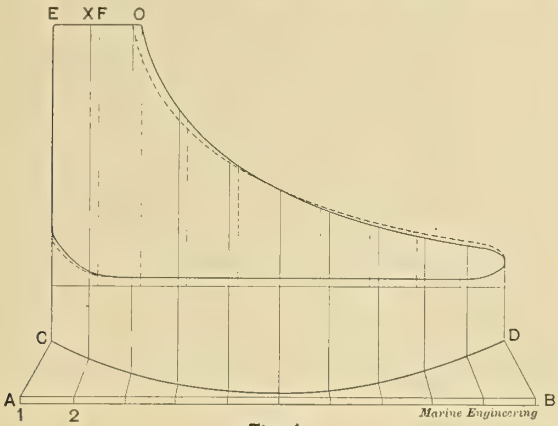


Fig. 1.

equal parts, by dotted lines, and the line A B, representing the engine's stroke, is also divided into ten equal parts. The arc C D represents the path of that point in the lever to which the cord is attached. Now, were the reducing motion perfect, the indicator drum would move through each tenth of its travel, while the crosshead moved through each tenth of its stroke, but this is impossible, because the crosshead moves in a straight line, while the point of the lever to which the string is fastened describes an arc.

Thus: While the crosshead moves from 1 to 2, the drum moves only from E to X, instead of from E to F, and so on throughout the stroke as shown by the unequal distances between the continuous and the dotted lines upon the diagram. There is, however, this difference, that whereas during the first half of the stroke the drum moves through a less proportionate distance than the crosshead, in the latter half of the stroke the drum moves through a greater proportionate distance than the crosshead. The misleading effect of this action upon the diagram is illustrated by supposing the cut-off to take place at O, in which case instead of the true diagram, we would obtain that shown by the dotted expansion and compression lines. The arc C D and the amount of distortion are here produced from actual conditions in a local steamer whose reducing gear is of the telescope style, one rod attached to the crosshead sliding within another pivoted on the engine column, and to whose outer end the cord is connected.

All such reducing motions not only distort the card as shown, but they make the M. E. P. and, therefore, the I. H. P. appear less than they actually are, and in estimating the horse power, etc., from the cards, when a lever reducing motion is used, the amount of error must be determined and allowed for if accuracy is desired. A system of pulleys, the larger of which engages the crosshead and the smaller the indicator cord, gives an accurate drum movement; the only objection to this system being the trouble, and often the difficulty, of fitting the pulleys in suitable positions. Among the best efforts to obtain uniformity of drum movement in indicator gear is that which the late Dr. Kirk fitted to the engines of the Propontis. A twisted flat bar was fixed in bearings parallel to and alongside of the column and on the crosshead an arm was fitted whose projecting end worked over the twisted bar so that as the crosshead moved the bar was partially rotated in the same way as the well-known twist drill brace. A small drum on the end of the bar provided means of connection to the indicator drum and a perfectly proportional movement was obtained.

Returning to the indicator itself. So delicate an instrument is readily affected by even slight derangement, and a few tests may from time to time be applied when engaged in important work. All parts of the indicator and its connections should be as good a fit as is consistent with free action.

(1) To test the freedom of the pencil movement remove the spring and the indicator piston, and see that the pencil falls freely from top to bottom; and with the piston connected, work the pencil up and down to detect any stoppage or gripping. Then with the thumb pressed over the hole through which steam enters the indicator, see that the pencil drops steadily from top to bottom and drops at once upon the thumb being removed.

(2) To test the truth of the drum motion, adjust the stop so that the pencil point is just clear of the drum, and move the pencil slowly from top to bottom and the drum from end to end of its travel to see that the clearance is equal throughout.

(3) Next put a strong spring into the indicator; and taking the pencil between the finger and thumb, press from side to side and up and down to detect any play in the joints.

Before attaching the instrument give the bearings a little oil, especially those which take the strain of the drum upon its spindle; they will fire, and cause the cord to break, if allowed to run dry. The indicator pipes should be of ample size with easy bends, well lagged, and with the cylinder ends clear of the piston at the end of its stroke. It is well to blow the pipes through before connecting the indicator, to remove any dirt or grit which may interfere with its action and cut the cylinder and piston. It sometimes happens that at high speeds the drum spring is too weak to prevent the drum traveling further than it should do, at the end of the stroke, owing to momentum. To detect this error trace the atmospheric line upon the card with the engine going dead slow, and then, lifting the card slightly upon the drum, open the engine to full speed and again trace the atmospheric line. The lines should be of equal length; if they are not equal the diagram will be distorted accordingly, and the cause must be looked for either in the drum itself or in the connections.

We may briefly state the three following conditions of steam before considering its action, as reflected in the indicator diagram:

(1) Dry saturated steam is steam in its best natural state, that is, holding the least possible amount of moisture in suspension while in contact with the water from which it is generated.

(2) Saturated steam is the term used when, owing to priming or imperfectly protected boilers, etc., an excess of moisture exists.

(3) Superheated steam is that which contains more heat than is due to its pressure at formation.

Thus exposed to atmospheric pressure, steam reaches only a temperature of 212 deg., but under a boiler pressure of 160 lbs. it has a temperature of 370 deg.; while if reduced in pressure, it is also reduced in temperature to a corresponding degree, by condensation taking place. Steam has, therefore, a specific temperature for each degree of presssure while in contact with the water of generation, but it may be made to contain more heat than naturally due to its pressure, either by superheating it in the ordinary way or by throttling or wire-drawing it. To illustrate this latter point let us suppose steam of 160 lbs. gauge pressure throttled to 140 lbs. Upon each side of the throttle valve the temperature is 370 deg., although the natural temperature of the steam at 140 lbs. is only 361 deg. This steam is, therefore, as effectively superheated as though its natural temperature had been raised to 370 deg. in a superheater. Strictly speaking, the temperature of the steam after throttling would be slightly less than 370 deg. on account of the internal work done; but the difference is not material to our illustration. We have said that the temperature and the pressure of steam in its natural state always correspond. One cannot alter without changing the other, and it has been proved that steam compressed at atmospheric presssure, while the 212 deg. is maintained, does not increase in pressure, because part of the steam is reconverted into water. And, reversing the process, if the steam be now expanded while the 212 deg. is maintained, the water formerly condensed again becomes steam upon its partial release from pressure. A familiar example of this latter action is afforded by Weir's contact heater and pumps. When the main engines are suddenly slowed or stopped, the water in the heater, being relieved from pressure, boils, causing the pumps to "slam," the water becoming steam of a pressure and a temperature corresponding to the new pressure in the heater. If this new pressure be that of the atmosphere, then the water in the heater resumes its state, as water, at 212 deg.

With this statement of the properties of steam we may consider the indicator diagram, and may compare the diagram obtained by an unstable gas, steam, with that which would be obtained by a perfect gas. Boyle's law, enunciated in 1662, is that "the pressure of a perfect gas at a constant temperature varies inversely as the space it occupies." That is to say, one cubic foot of gas at 100 lbs. pressure when expanded into two cubic feet would be reduced to half its original pressure, or 50 lbs.; if expanded into four cubic feet its pressure would be 25 lbs. and so on.

Fig. 2 shows graphically the expansion of a perfect gas by Boyle's law, the diagram being divided into equal divisions as shown. Cut-off takes place at C, and the gas expands. At 3 its pressure is two-thirds of A B, at 4 two-fourths of A B measured from the perfect vacuum line. A B C D E is an ideal diagram in which A E is the line of perfect vacuum. Pressure is admitted to the piston at the atmospheric line above A, when the indicator pencil rises to a point B, corresponding to the presssure in the cylinder, and the piston begins its forward stroke. On cut-off occurring at C, the gas behind the piston acts expansively to the end of the stroke D. Here the exhaust opens, the pressure falls to the line of perfect vacuum E, and the piston makes its return stroke, at the end of which, at A, the exhaust closes and the steam port opens; the pencil rising to B, as before. In this ideal diagram the effect of clearance on the expansion curve is not shown; the gas is admitted at initial pressure to the point of cut-off; the expansion curve follows Boyle's law; the exhaust opens and closes at the end of the stroke only; the valve is instantaneous in its action, and a perfect vacuum is realized in the cylinder.

In practice none of these conditions are obtainable. Clearance is a mechanical necessity; the boiler pres-

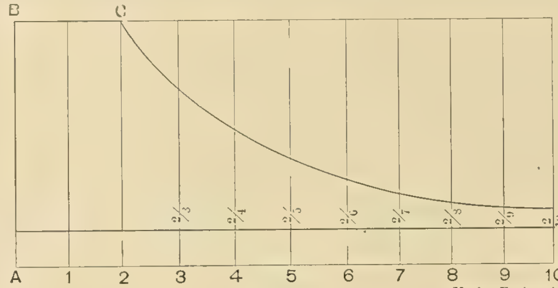


Fig. 2.

sure is seldom realized in the cylinder, and the action of the valve is not instantaneous. A perfect vacuum is not obtained, nor does the expansion curve agree with Boyle's law. Also for practical reasons, it is necessary to open the exhaust before the end of the stroke, and to close it before the end of the return stroke, so that, instead of the theoretically perfect Fig. 2, we obtain in practice a diagram resembling Fig. 3, in which P V is the line of perfect vacuum;

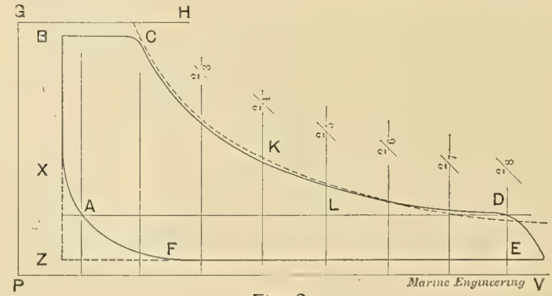


Fig. 3.

A L the atmospheric line; X B the admission line; B C the steam line; C K D the expansion line, and G H the line of boiler pressure. The dotted curve is that due to the application of Boyle's law. At C the steam is cut off and expands behind the piston to D, where the exhaust opens, and the pressure falls to E. The piston performing its return stroke, the pencil traces the back pressure line E F, at the end of which, at F, the exhaust closes and the piston, still returning, compresses the steam shut in the cylinder to a pressure X, the pencil tracing the compression line F X; at X the steam is admitted for the next forward stroke. The distance betwen the vertical lines X B and P G is the clearance, and this point may be considered more fully. In the theoretical diagram, Fig. 2, the engine is supposed to be without clearance, so that at the point of cut-off the steam to be expanded is simply that contained in the space swept through by the piston. But, in practice, we have not only the space swept through by the piston to the point of cut-off, but also that space occupied by the steam between the piston when at the end of its stroke, and the valve face, that is, the clearance as usually understood added to the volume of one steam port; and this total volume, plus the volume swept through by the piston to cut off, gives the actual volume of steam to be expanded.

Fig. 3 shows a method of laying off the clearance upon the card and of finding the resulting theoretical curve. To find the clearance, the most accurate plan is to place the engine on the center, and having filled in tallow round the edge of the junk ring to prevent leakage into or through the piston, fill the space betweeen the cylinder cover and the valve face with water of a known weight and temperature; the valve must be removed and the steam port covered with a suitable piece of wood smeared with tallow and blocked firmly up to the cylinder face. The water may then be poured in through any opening in the cover, such as the escape valve seat. Having found the weight of water occupying the clearance spaces, convert that quantity into cubic inches, making any necessary correction for temperature. Suppose, for example, the water amounts to 100 cu. in., and that the volume swept through by the piston is 1,000 cu. in.; then the clearance would be one-tenth the volume swept through, and the clearance line must add one-tenth to the length of the diagram. Erect, therefore, the clearance line at this distance upon the card, draw a perpendicular line through the point of cut-off, divide the space between this point and the clearance line into any number of equal spaces, and continue these distances along the diagram, as shown. The theoretical curve may then be found as already described. It is evident that clearance spaces may be a source of loss, because at each revolution they are filled with steam which is exhausted to the condenser or to the line of back pressure without doing work upon the piston. This loss may be largely overcome by closing the exhaust before the end of the stroke as at X in Fig. 3, so that the exhaust steam is compressed to nearly initial pressure, and the incoming steam finds the clearance already filled to a pressure X. Only the quantity of steam X B is now required before the piston moves, instead of the quantity Z B, which would be required were there no compression. Quite apart from economy, as described, compression, by absorbing the inertia of the moving parts, gives a smoothly working enine and reduces the wear of brasses and the oil required. It also reduces the wear and tear of the human element, the engineer, a point which is often lost sight of.

Referring again to Fig. 3, it may be noted that the expansion line C K D falls at first below and afterward rises above the dotted theoretical line; and this enables us to compare the action of steam within the cylinder with that of a perfect gas. In the first place, the boiler pressure never is realized in the cylinder, because of the losses which occur through friction in pipes and passages, and sometimes through wire-drawing by insufficient port opening, etc. Upon entering the cylinder the steam is further condensed by contact with the cylinder walls chilled from the previous exhaust; and to make up for this condensation, and maintain initial pressure to the point of cut-off, supplementary steam is drawn from the boiler. Experiment has proved that on entering the cylinder the steam has suffered condensation to the extent of from 25 per cent to 60 per cent, and that the loss from this cause is greater in slow moving engines, with an early cut-off, than in quick engines with a late cut-off, because, in the latter engines the range of high temperature being better maintained, the cooling due to exhaust is less. When expansion begins, the steam comes in contact with still more chilled cylinder surface; the steam continues to condense; and, being no longer able to draw upon the boiler for compensation, its pressure falls below the theoretical curve, as at K in Fig. 3. At this point we have, besides the steam in the cylinder, sundry films of water clinging to the internal surfaces; and, as expansion proceeds, a point is reached at which the temperature of the steam becomes less than that of the films of water. These latter then evaporate, as in the example of the Weir's heater, the pressure in the cylinder is slightly increased, and the expansion line of the diagram rises above the theoretical line, towards the end of the stroke. Should the expansion line rise much above the normal, we should conclude that steam was being admitteu after cut-off, probably through a leaky valve, while if the actual expansion curve fell below what might reasonably be expected it would indicate a leaky piston, especially if accompanied by a rise in the back pressure line.

The theoretical diagram is more nearly approached in stationary than in marine practice, because with the ordinary link motion it is difficult to obtain the sharp valve action characteristic of the Corliss and similar engines; the comparatively short stroke and greater clearance of marine engines are also against it in the production of the best type of diagram.

Fig. 4 is a diagram from a Corlisss engine, and is selected as an example of how nearly the theoretical curve may be approached in practice and also as showing the indicator's value in depicting this action, and in revealing faulty valve setting. The diagram is in no way intended as a show card, but was taken under every-day conditions to test the working of the engine. The scale of the diagram is 40 lbs. to the inch, and the boiler pressure 80 lbs. by gauge. A is the atmospheric line of the instrument; B the actual vacuum; D the boiler pressure; E the end of the stroke or what should be the admission line; F the long dotted line, the theoretical curve; and G, the finely dotted line, the actual curve. The distance between the lines C and E is the clearance. The admission line by leaning from the perpendicular shows plainly that the steam admission is late, the piston having traveled about 2 1-2 in. at E before it feels the steam properly. This is probably the reason why the steam line is imperfectly maintained and droops somewhat as the piston advances. The cut-off is sharp (sharper than could be obtained with ordinary link motion) and the expansion line is very

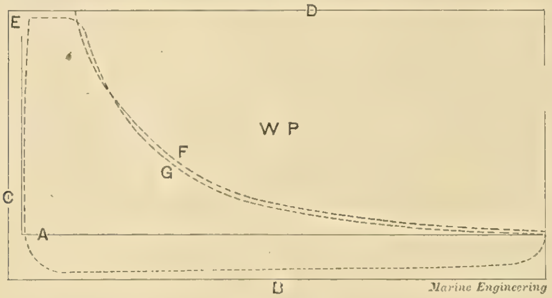


Fig. 4.

good, dropping below the theoretical line as cylinder condensation takes place, and rising as the condensed steam is re-evaporated. The exhaust is late, not opening until the piston reaches the end of its stroke, as shown by the sharp corner at the termination of the expansion curve; and, owing to this late action of the valve, the exhaust gets away with difficulty, and the best effect of the condenser is not obtained until the piston reaches the end of its return stroke. This engine requires the lead increased to make E the admission line; and the exhaust valve should open earlier by about 3 in. of the stroke. This would have the effect of enlarging the diagram at E, and also of increasing the mean effective pressure by allowing the exhaust to get freely away so that the maximum vacuum would be at once realized. By working out the area of the figure which would thus be obtained and comparing it with the present diagram, it may be seen that the area of the diagram, and therefore the power of the engine, would be considerably increased by the slight alterations in valve setting referred to.

Diagrams Nos. *a* and *b*, Fig. 5, are taken from the report of Henry Hillier, chief engineer of the National Boiler Insurance Company of Manchester, England, and they form a pretty good example of the misuse of steam. The diagrams are taken, *a* from one cylinder, and *b* from the other cylinder, of a pair of non-condensing engines working together; boiler pressure 57 lbs. The scale of *a* is 22, and that of *b* 12 lbs. to the inch, and the figures on *a* are those given by the planimeter. Mr. Hillier remarks, "One of the engines was actually doing no work, but was really being driven by the other. One of them they stopped at our suggestion, and the water consumption, as shown by the diagrams, reduced from 66 to 35 lbs. per indicated horse power per hour." These diagrams are peculiar in more respects than one. The first (*a*) is very late in taking steam, and the steam is badly wire-drawn. The expansion lines are wretched and the effective pressure is greater at one end than at the other. Sixty-six pounds of steam per I. H. P. per hour is an outrageous quantity. The other (*b*) is more than peculiar. The steam is admitted, cut off sharply and expanded across the atmospheric line at about one-fifth of the stroke; and those portions of the diagram below the atmospheric line are larger than those above it, so that the engine is doing less than no work, and is actually being pulled round by the other engine. As shown the horse power of *b* is minus 2.5, so that the whole of the steam used in that cylinder is worse than wasted. And in *a*, only 38 lbs. of steam out of 57 lbs. boiler pressure is utilized on the piston, and then not until the piston has been some time on its way, so that the steam never catches it up, and the diagram proves the truth of the old adage that a stern chase is a long one. We do not wonder that when one engine, as Mr. Hillier advised, was stopped the other engine did all the work with less steam.

Fig. 6 is a diagram from the low-pressure cylinder of the compound engine of the steamship Kiung-Chow, and here the effect is seen of a very small volume in the receiver between the cylinders. The expansion line of the L. P. diagram rises in a most unusual manner towards the latter end of the stroke, and this is owing, as stated, to the smallness of the receiver, which consisted simply of a pipe conveying the H. P. exhaust to the L. P. cylinder. When the L. P. piston began its stroke at B, the H. P. exhaust

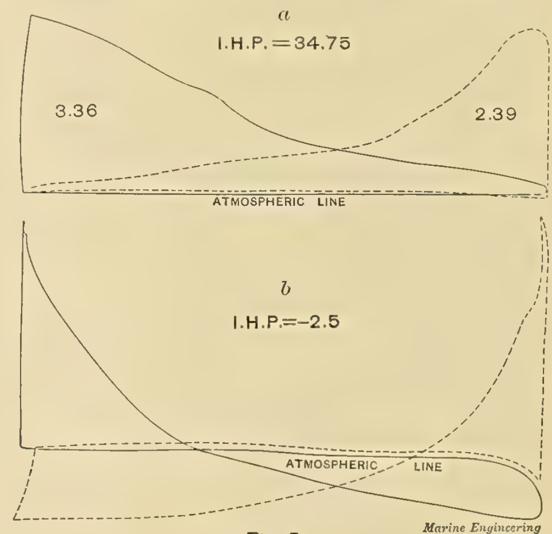


Fig. 5.

was closing, and the contents of the pipe being unable to maintain the pressure in the L. P. cylinder, the pressure dropped to E, and on the H. P. exhaust entirely closing, to C. At C, the exhaust from the opposite end of the H. P. cylinder opened, and the steam port of the L. P. cylinder being also open,

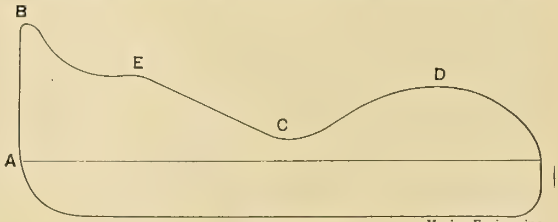


Fig. 6.

owing to the late cut-off, the pressure in the L. P. cylinder rose to D as shown. Cut-off quickly followed by exhaust then took place in the L. P. cylinder and the steam was discharged to the condenser at a wastefully high pressure. This would have been prevented by an earlier cut-off in the L. P. cylinder.

RESULTS OBTAINED BY THE INDICATOR.

(1) The indicator diagram is a picture of the steam's action in the engine cylinder. From it may be judged the sufficiency of the lead; the point of cut-off; with what degree of perfection the steam pressure is maintained to this point, and the difference between the initial pressure in the cylinder and that in the boiler.

(2) The diagram shows the expansion of steam within the cylinder; at what parts of the stroke the exhaust is opened and closed, and the degree of back pressure upon the piston at every point. The pressure at any part of the piston's stroke and the mean pressure throughout the stroke may be obtained, and from the mean pressure, together with the speed and size of piston, may be calculated the horse power of the engine. The diagram also enables us to compare the actual expansion of the steam with ideal conditions, and affords us approximately the percentages of cylinder clearances.

(3) By combining the diagrams from multiple-expansion engines the drop between each cylinder may be shown, and the difference between the actual curve of expansion and the theoretical curves graphically shown.

(4) By the steam line is shown whether the steam attains its due pressure in the cylinder and is maintained at full pressure to the point of cut-off, or whether, owing to contracted passages or steam pipes, or insufficient port opening, it is wire-drawn, and if so to what extent. The steam line of the intermediate or of the low pressed cylinder also shows the proportion of the receiver capacity to the volume of steam exhausted into it.

(5) By the appearance of the point of cut-off may be seen how nearly the sharp cut-off demanded by economy is approached; while, within certain limits, leakage of valves or piston may be detected by comparing the expansion curve with a theoretical curve or with that of a diagram previously obtained from the same engine when in good order. In paddle steamers fitted with double-beat valves the leakage due to unequal wear of the valves may often, after a few months' work, be detected by the fuller expansion line of the diagram as compared with the cards taken just after the valves had been ground up.

(6) From the position and appearance of the exhaust corners of the card the engineer may judge of the economy of his engine in these particulars; if a quick working engine whether the exhaust opens early enough and whether the compression is in excess of that required for quiet running or whether it may be decreased or increased with advantage.

(7) The back pressure line shows, in a high pressure or intermediate diagram, whether the exhaust opening is sufficient; and in addition to this, in a low pressed card it shows the perfection of the vacuum and with what degree of regularity the vacuum is maintained throughout the stroke. In slow working engines, such as paddle engines, and in which a single-acting air-pump is worked by the engine itself, diagrams taken on the same card from the top and bottom of the L. P. cylinder sometimes appear with one back pressure line higher than the other, showing that on the up stroke of the air pump the vacuum is more perfect than on the down stroke.

(8) In estimating the twisting strain upon shafting the indicator is invaluable, for without it could not be found the strain upon the piston and therefore that upon the shaft. But from the indicator diagram and a knowledge of the speed and weight of the engine's moving parts may be constructed a curve of rotative effort showing the twisting strain upon the shafting at every point of its revolution. By this means the superiority of double over single, of triple over double, and of quadruple over triple cranks is made very apparent as regards their nearness of approach to regularity of crank effort, and a more intelligent idea may be formed of the fitness of the shafting to withstand the strain upon it.

So far the indicator has been considered only in relation to the steam engine cylinder, but it may be applied to the valve casings and motion obtained either from the crosshead or the valve spindle; it may also be applied to the pumps. In these cases its action is similar to that already described, and the figures obtained under various conditions are most interesting and instructive. The diagrams from a pump in good order are usually parallelograms with serrated corners; leakage of the plunger or of the suction valves causes rounding of the corners of the diagrams. Diagrams from pumps, although showing the action of the water within the pump chambers, do not indicate its true pressure if the ordinary springs are used, because these springs are correct only at the temperature of the steam for which they are marked. If used at any other temperature, and accuracy be desired, allowance must be made for the altered temperature, or suitable springs obtained from the makers.

To the indicator and its intelligent use we are largely indebted for our advances in marine engineering. It has been the means of revealing defects of arrangement and construction in the cylinders, valves, passages, etc., thereby apart from economy, improving the working of the engine, and by more uniform motion and better distribution of strain on the working parts, adding to the life of the machine. The indicator has been the means also of confirming the theory of liquefaction and re-evaporation in the cylinders, etc., and it has assisted designers to furnish a better proportioned, more economical, and better running engine. The genius, Watt, that gave to the world a commercially successful motive power, also placed in our hands an instrument which gives at once a measure of that power and an indication of its efficiency.

During the recent Spanish war 4,216 members of the Naval Militia were enlisted in the regular navy.

A favorable report on the Holland submarine boat has been made by a naval board and the boat will soon be subject to an actual war test, firing loaded projectiles at a floating vessel. Should this test be successful the boat will probably be purchased by the Government.

PURCHASE PRICE PAID BY THE NAVY DEPARTMENT FOR WARSHIPS AND AUXILIARY VESSELS ON ACCOUNT OF THE SPANISH WAR.

Abarenda	Abarenda	J. Graham	$175,000	Kanawha	Kanawha	John P. Duncan	$50,000
Active	Active	J. D. Spreckles & Co	75,000	Kate Jones	Seminole	Boston Towboat Co	25,000
Aileen	Aileen	Richard Stevens	55,000	Kingston	Cæsar	John Holman & Sons	175,194
Alicia	Hornet	Henry M. Flagler	117,500	Lebanon	Lebanon	Phila. & Reading R. R. Co	225,000
Alice	Alice	John M. Worth	19,000	Lucilene	Arethusa	Thomas S. Hopkins	218,992
Almirante Abru	Albany	Brazilian Government	1,205,000	Mayflower	Mayflower	Ogden Goelet Est	430,000
Almy	Eagle	Frederick Gallitin	110,000	Menemsha	Iris	Miami Steamship Co	145,000
Amazonas	New Orleans	Brazilian Government	1,429,215	Merrimac	Merrimac	Hogan Line	342,000
Atala	Alexander	New Star Blue Line	206,826	Nanshan	Nanshan	Frank Smythe	155,728
Atlas	Wampatuck	Standard Oil Co	65,000	Niagara	Niagara	Ward Line S. S. Co	200,000
A. W. Booth	Massasoit	Moran Towing Co	30,000	Nictheroy	El Cid, Buffalo	Brazilian Government	575,000
Bristol	Cheyenne	J. J. Cummings	20,000	No. 18	No. 18	Phila. Trans. & Light Co	2,800
Celtic King	Celtic	Federal Line	340,900	No. 55	Water Barge No. 1	Standard Oil Co	24,000
C. G. Coyle	Chotaw	W. G. Coyle	82,500	No. 295	Sylph	John Roach & Co	50,000
Chatham	Vulcan	Merchants & Miners Line	350,000	Norse King	Rainbow	Thomas Ronaldson	176,576
Columbia	Wasp	J. H. Ladew	95,000	Not named	Manly	Charles R. Flint	24,250
Comanche	Frolic	H. M. Hanna	115,000	Not named	Somers	Schichau Iron Works	72,997
Confidence	Waban	M. Revel	20,000	Pedro	Hector	A prize capture	200,000
Corsair	Gloucester	J. Pierpont Morgan	225 000	Penelope	Yankton	H. E. Converse	125,000
Creole	Solace	Cromwell S. S. Line	600,000	Penwood	Powhatan	Walsh & Doran	42,500
D. C. Ivins	Nezinscot	Moran & Co	30,000	Peter Jebsen	Brutus	L. F. Chapman & Co	215,000
Diognes	Topeka	Thames Iron Works	170,327	Philadelphia	Peoria	Phila. Pilot Association	100,000
Dorothea	Dorothea	Thos. McKean Est	187,500	P. H. Wise	Sioux	Moran & Co	25,553
East Boston	East Boston	City of Boston	57,500	Port Chalmers	Glacier	Federal Line (London)	340,550
Ed. Luckenbach	Tecumseh	Luckenbach & Co	45,000	Ravenna	Scipio	George P. Walford	85,769
Elfrida	Elfrida	Dr. Seward Webb	50,000	Refrigerating Ship			247 704
Eliza Holland	Leonidas	Francis Stanley Holland	147,941	Restless	Restless	Hiram W. Sibley	29 000
El Norte	Yankee	Southern Pacific Co	575,000	Rhaetia	Cassius	William Lamb	160,594
El Rio	Dixie	Southern Pacific Co	575,000	Right Arm	Pontiac	Merritt & Chapman	30,000
El Sol	Prarie	Southern Pacific Co	575,000	Saturn	Saturn	Boston Towboat Co	290,000
El Sud	Yosemite	Southern Pacific Co	575,000	Scindia	Scindia	Henderson Bros	267,657
El Toro	Accomac	So. Pacific Co	40,000	Shearwater	Shearwater	Henry R. Walcot	26,000
Enterprise	Modock	American Towing Co	30,000	Southery	Southery	Ed. Luckenbach	100,000
Enquirer	Enquirer	W. J. Conners	80,000	Sovereign	Scorpion	M. C. D. Borden	300,000
Eugenia	Siren	J. G. Cassatt	40,000	Sterling	Sterling	Black Diamond Trans. Co	190,000
Fearless	Iroquois	J. D. Spreckles & Co	150,000	Stranger	Stranger	Mrs. Mary Lewis	75,000
Gov. Russell	Gov. Russell	City of Boston	71,000	Sylvia	Sylvia	Edward M. Brown	25,000
Harlech	Pompey	Jas. & Chas. Harrison	111,929	Thespia	Hist	David Dows, Jr	65,000
Hercules	Chickasaw	M. Revel	15,000	Titania	Marcellus	William Lamb	90,000
Hercules	Hercules	Standard Oil Co	40,000	T. P. Fowler	Mohawk	Cornell Steamboat Co	44,000
Hermione	Hawk	Henry L. Pierce Est	50,000	Venezuela	Panther	Red D. Line S. S. Co	375,000
Hortense	Takoma	O'Connor & Smoot	28,000	Vigilant	Vigilant	J. D. Spreckles & Co	60,000
Huntress	Huntress	F. C. Fowler	27,500	Viking	Viking	Horace A. Hutchins	30,000
Illawara	Oneida	Eugene Tompkins	60,000	W. A. Luckenbach	Uncas	Luckenbach & Co	75,000
Illinois	Supply	International Nav. Co	325,000	W. H. Brown	Piscataqua	W. H. Brown	130,000
Inca	Inca	Frank B. McQuesten	35,080	Whitgrift	Nero	McCondray & Co	215,000
J. D. Jones	Apache	Merritt & Chapman	54,510	Wilmot	Potomac	Ocean Tow and Wrecking Co	125,300
John Dwight	Pawnee	George T. Moon	25,000	Winthrop	Osceola	Staples Coal Co	100,000
Joseph Holland	Hannibal	Francis Stanley Holland	147,941	Yorktown	Resolute	Old Dominion S. S. Co	475,000
Josephine	Vixen	P. A. B. Widener	150,000	Yumuri	Badger	Ward Line S. S. Co	367,000
Justin	Justin	Bowring & Archibald	145,000	Zafiro	Zafiro	China and Manila S. S. Co	87,597

In the annual report of Secretary of the Navy John D. Long, the cash prices paid by the Government for warships and auxiliary vessels during the recent Spanish war are given. They are here published in the alphabetical order of the original names of the vessels. During the progress of the war our readers will recollect that we published, from time to time, lists of these vessels giving their chief characteristics and, consequently, by the use of these lists in combination with the above table a brief history of each vessel will be obtainable. In addition to the vessels included in the present list these large ocean liners were chartered: City of Pekin, on the Pacific coast, at \$1,000 a day; S. Ss. St. Paul and St. Louis; New York (U. S. S. Harvard) and Paris (U. S. S. Yale), of the American Line, on the Atlantic coast, at \$2,500 a day each for the two first named, and \$2,000 a day each for the two others. While in the U. S. service these vessels were loaned to the War Department for several days for use as transports. The municipality of Philadelphia loaned an ice boat (U. S. S. Arctic) for the nominal consideration of \$1.00, and the steam yachts Free Lance and Buccaneer were loaned for service without charge by the respective owners, F. Augustus Schemerhorn and W. R. Hearst, of New York.

Ship's Bell for U. S. S. Princeton.

Our illustration shows the exceedingly handsome and artistic ship's bell presented to the U. S. S. Princeton by the Alumni of Princeton University at the Navy Yard in Brooklyn, December 10. In addition to this bell a well selected library of 600 volumes, with the necessary cases, and a silver punch bowl were presented to the ship by the Princetonians. In dimensions the gift is rather larger than the regulation ship's bell. It is made of bronze, and is loud and agreeable in tone. Thomas Shields Clark, a Princeton graduate, is responsible for the design, which shows old Nassau Hall in relief with the date of its foundation, 1746, as the central figure. The clapper, above the ring, shows the tiger, typical of Princeton,

BELL PRESENTED TO U. S. S. PRINCETON.

engaged in conflict with the bulldog, typical of Yale; emblematic of the athletic contests between these two great American universities. The presentation address was made by M. Taylor Pyne, of New York, and the bell was accepted in behalf of the ship's company by Commander Clifford H. West, U. S. N. The presentation was made the occasion of a very enjoyable social function.

"THE DOCTOR" AS MET WITH IN WESTERN RIVER STEAMBOAT PRACTICE.

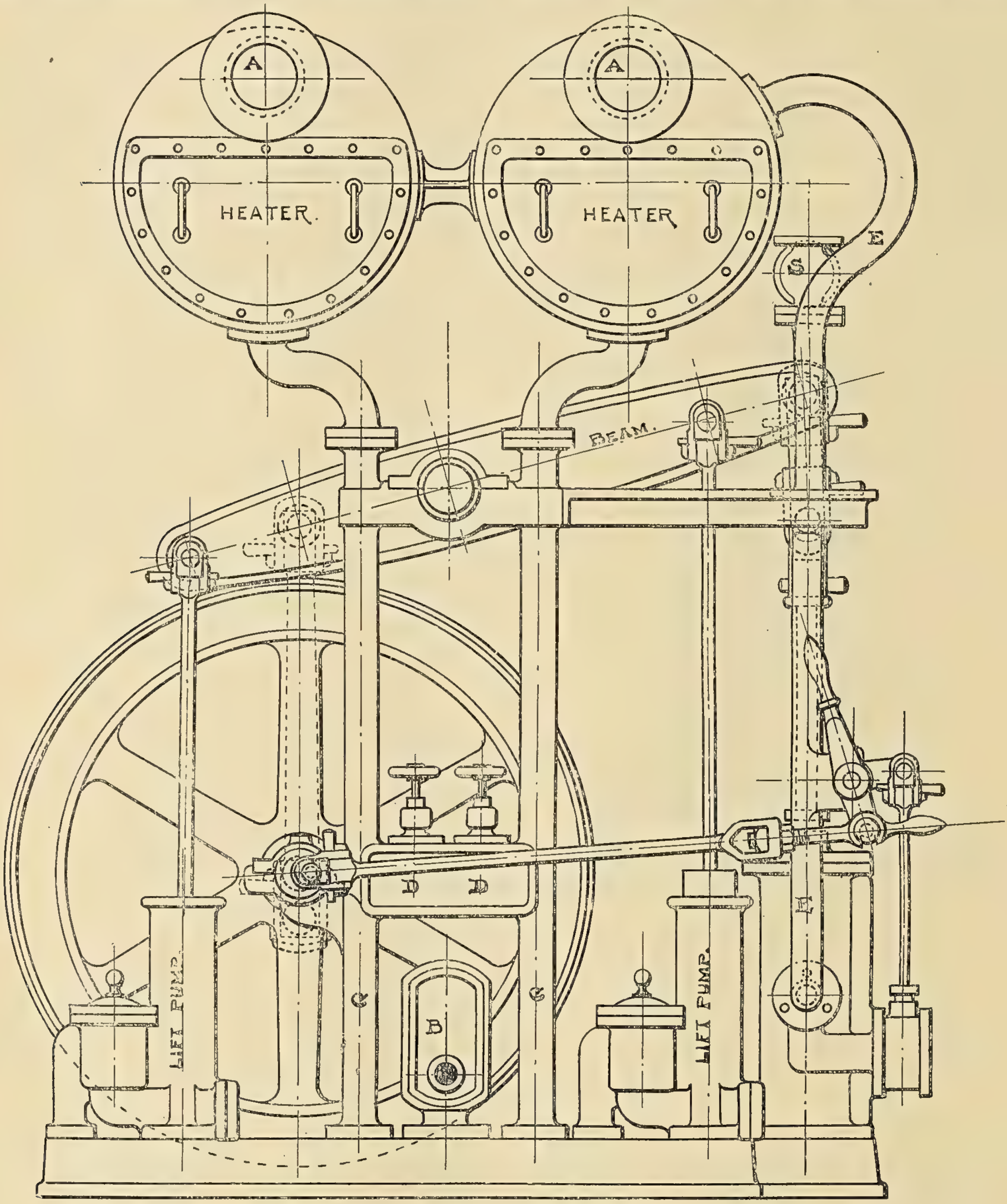
Many of our readers will recollect that more than a year ago we published an extensive description of an Ohio river steamer, the Queen City, as a representative example of western river practice. In describing the machinery of this particular steamer, mention was made that the old-fashioned "Doctor" was missing, the boilers being supplied with feed water by two injectors of the most modern type. These injectors are certainly more easy to handle and occupy considerably less space; but while they can be used to advantage and give the best of satisfaction on the upper portions of the Ohio river, they could not be used in all localities on account of the excessive amount of sand and grit that is held in suspension by the water in certain districts lower down the river. This would cut away the injector tubes so rapidly that they could not be depended upon. For this reason the "Doctor" will hold his own in such localities, and remain a most important detail upon many of the western river steamers.

Upon many of the lower river steamers the "Doctor" will be found standing in all of his ancient glory, having Corinthian columns, braced by Gothic arches, forming supports for the overhead working beam and other details; with all of the various connecting rods ornamented with numerous collars, bands, beads and fillets, which testify to the vast amount of time and labor expended upon such work in former times. Occasionally an example is seen where the old style parallel motion is used, in place of the guide and cross head, as well as other reminders of the past. Other types will be found, too, more simple in design, showing that they are of more modern construction.

The "Doctor" shown in the illustrations is one of the "modern school" and consists of a vertical beam engine, with crank and fly wheel, operating four pumps. Two of these are simple lift pumps, drawing water from the river and discharging it into open feed water heaters over head, while the other two are feed pumps taking their supply from the heaters and forcing the water into the main boilers. Each force and lift pump is designed to have ample capacity to feed the entire battery of boilers, so that any one of the pumps may be disconnected for examination or repair without danger, although in practice the machine is more perfectly balanced when all of the pumps are in service.

The base plate, upon which the various details are erected, is deep, and contains numerous ports and passageways which form the water connections between the various parts of the pump. The suction pipe, from the river, is connected with the vacuum chamber B, and communicates through a passage in the base casting with the suction side of the two lift pumps; the discharge from these pumps is also connected by similar passages to the columns C-C, which serve as discharge pipes, beam bearing columns, and heater supports. Near the center of these columns are located valves D-D, which can be closed to prevent the water in the heaters from returning at such times as it is necessary to open up a valve case for examination or repair. The heaters A-A consist of wrought iron shells riveted to cast iron heads through which the exhaust steam from the main engines passes on its way to the exhaust pipes. This exhaust steam comes in direct contact with coils of copper pipe that lie in the lower part of the heaters, through which the feed water is forced and finally discharged below a diaphragm. Although the diaphragm does not prevent the exhaust steam from coming in direct contact with the water, it acts as a baffle plate and also as an oil separator, being arranged with an overflow pipe which prevents flooding the head of water being sufficient to flood the valves and prevent the feed pumps from missing stroke on account of vaporization of the heated water.

The lift pumps are fitted with long pistons, having cup leather packing in some cases, and in others square gum packing fitted into suitable grooves is



FRONT ELEVATION.

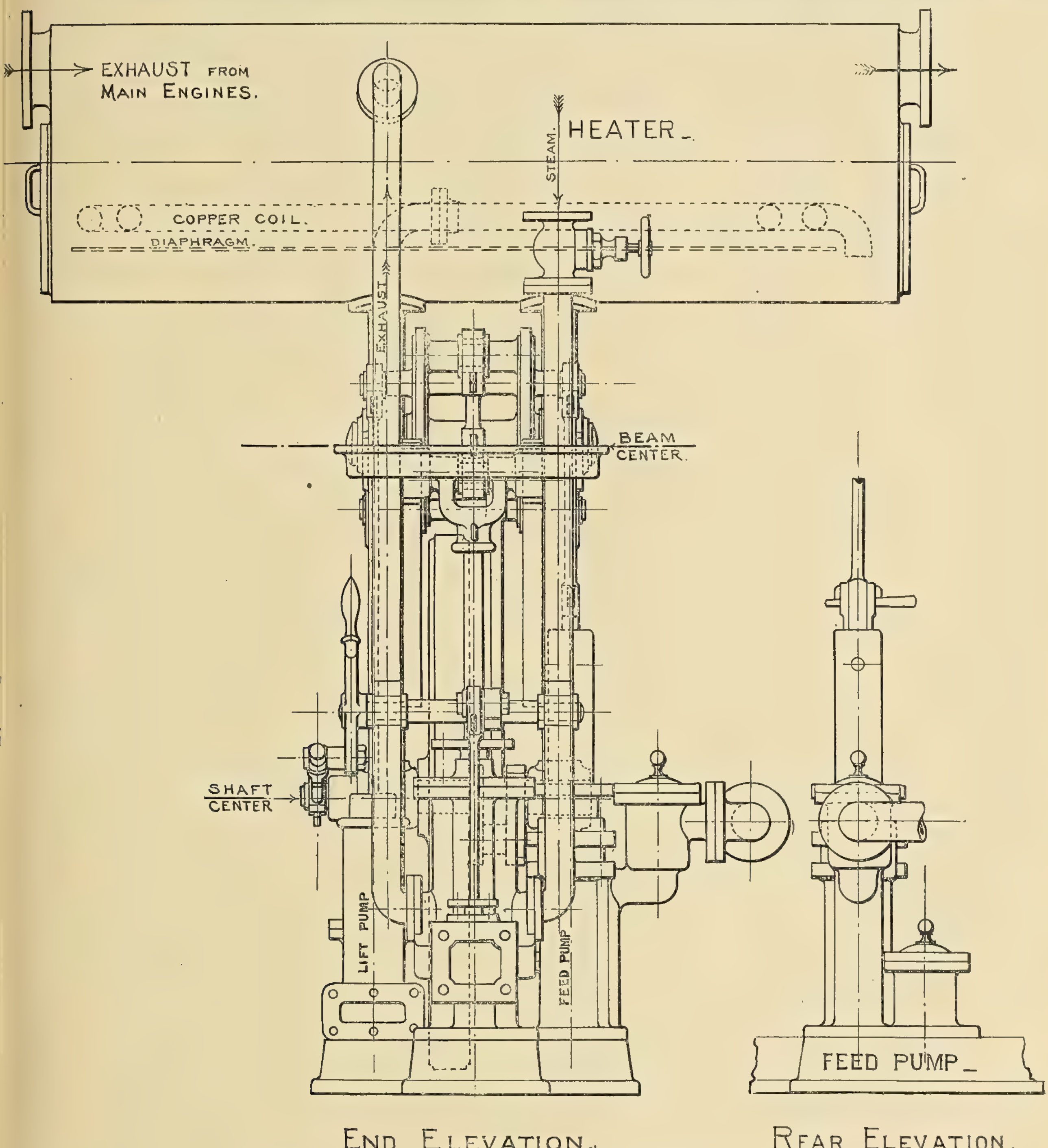
MODERN TYPE OF "DOCTOR" IN SERVICE ON WESTERN RIVER STEAMBOATS.

as well as to remove all oil that may float upon the surface of the water.

Upon the opposite side are columns similar to C-C through which the heated water flows to the base plate and to the suction valves of the feed pumps, used, while the feed pumps are arranged with outside packed plungers having deep stuffing boxes and heavy glands fitted to the pump barrels.

The pump valves are flat disks of brass properly guided and fitted to flat brass seats. The valves are made extra heavy, being 2 1-2 in. thick in some cases, so as to avoid the necessity of springs and at the same time allow ample metal for the purpose of facing off, as it is often found necessary to true up these valves after a round trip.

The engine portion of the outfit is simple in construction, as will be seen by an examination of the drawings, the most noticeable feature in the design being the manner in which the steam and exhaust pipes are utilized to form the supports for the guides upon which the cross head slides. All of the working parts are simple in construction and very accessible, and in the river service, working all kinds of water against high pressures the "Doctor" has proved effective and economical. There is room for improvement, however, and this is a good field in which the manufacturers of high grade steam pumps may show their skill in designing a "Doctor" that will be strictly of the "New School," be more economical than his predecessor, accessible, easy to repair and earn a position which will be at the very head of the "profession" for river service.



MODERN TYPE OF "DOCTOR" IN SERVICE ON WESTERN RIVER STEAMBOATS.

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AN extensive programme for additions to the Navy has been mapped out by Secretary Long, and will in all probability be agreed to by Congress. It contemplates the addition to the Navy of fifteen effective fighting vessels, ranging from battleships of the first class to third-class cruisers, rather larger than the present "Detroit" class. In detail the vessels recommended are:

Three seagoing sheathed and coppered battleships of about 13,500 tons trial displacement, carrying the heaviest armor and most powerful ordnance for vessels of their class, and to have the highest practicable speed and great radius of action. Estimated cost, exclusive of armor and armament, $3,600,000 each.

Three sheathed and coppered armored cruisers of about 12,000 tons trial displacement, carrying the heaviest armor and most powerful ordnance for vessels of their class, and to have the highest practicable speed and great radius of action. Estimated cost, exclusive of armor and armament, $4,000,000 each.

Three sheathed and coppered protected cruisers of about 6,000 tons trial displacement; to have the highest practicable speed and great radius of action, and to carry the most powerful ordnance suitable for vessels of their class. Estimated cost, exclusive of armor and armament, $2,150,000 each.

Six sheathed and coppered cruisers of about 2,500 tons trial displacement; to have the highest speed compatible with good cruisng qualities, great radius of action, and to carry the most powerful ordnance suited to vessels of their class. Estimated cost, exclusive of armament, $1,141,800 each.

It will be noticed that all these vessels are sheathed and coppered, a departure from our regular practice, though one much use in other navies, especially the British. The only vessels of this construction now in our service are the U.S.S. New Orleans, formerly the Amazonas, built in England for the Brazilian Government, and the U.S.S. Albany, now under construction at Newcastle-on-Tyne. This increase to the present fleets built or building would give a total of fifteen first-class battleships, five first-class armored cruisers, six first-class protected cruisers and nine third-class unprotected steel cruisers. The battleships proposed would be considerably larger than those now afloat or even than those recently contracted for. The armored cruisers would be very much larger than either the "New York" or "Brooklyn." The first-class protected cruisers would be rather larger than Admiral Dewey's famous flagship U.S.S. Olympia, and, of course, possessed of many improvements in armor and armament and steaming capacity. The third-class cruisers would be practically a new type, and valuable additions to a class which is now represented by but three modern vessels. Altogether the programme is a well considered one, and if carried out will add greatly to the strength and dignity of the United States in its commercial relations with other maritime countries.

WE have been asked why the Government should expend a large sum of money in the construction of new vessels of the destroyer type, when among the personnel of the Navy there is such an efficient corps of torpedo-boat destroyers? Well, the answer is simple enough: The true mission of a destroyer is to disable or render ineffective the torpedo-boats of the enemy, while the destroyers our questioner refers to are, unfortunately, charged with the operation of our boats, so that instead of a means of offense they become a menace to our fleets. Another gentleman, a member of the Society of Naval Architects and Marine Engineers, who by position and training is well qualified to speak, writes taking exception to a statement made by Lieutenant-Commander W. W. Kimball, U.S.N., in a paper by that officer read before the recent meeting of the Society. This letter will be found elsewhere in these columns. The statement that our correspondent challenges reads:

We have only very few officers of the Engineer Corps competent to give trained engineering supervision to those repairs on torpedo-boats which we attempt at Navy Yards, and those few are rarely available for the duty.

We cannot take the serious view of this statement which our correspondent does, and in fact we believe he lays himself open to the charge of a lack of appreciation of humor. Allowing Mr. Kimball's statement about the professional ability or incapability of our engineer officers, is there not a delightful touch of infantile roguishness about his remark? After members of his command had done all in their power (not maliciously, only ignorantly) to render useless the boats intrusted to his care he complains that the engineers are not able to repair them. Just as a child might break his Christmas toy and then blame his parent for not having skill enough to mend it. Even taking our correspondent's view he has, apparently, missed another subtle point of the doughty Lieutenant-Commander's humor, for he has not noted the significance of the word "attempted" in the original. Mr. Kimball does not admit that the Navy Yards can make repairs at all, though he concedes they may "attempt" such repairs. There is a world of difference between repairs "attempted" and repairs "effected." Many a boy with a mechanical turn of mind has "attempted" repairs to the family clock, only to be chastized for his pains. It was unfortunate, however, for Mr. Kimball to indulge in his humor on this point; he must have forgotten the old saying about living in glass houses. The facts in the case can be readily stated. When the Spanish war broke out there was at once felt that lack of trained naval engineers to which Commodore Melville, Engineer-in-Chief of the Navy, had called public attention time and again. So when the torpedo flotilla was assembled in home waters and placed in command of Lieutenant-Commander W. W. Kimball, there was only one engineer officer available for the entire lot of vessels—Passed Assistant Engineer O. W. Koester, U.S.N., who was attached to the "Ericsson." The flotilla consisted of the boats Ericsson, Porter, Rodgers, Dupont, Foote and Cushing. This gave one engineer officer to more than 14,000 indicated horse power of the most delicate machinery afloat. When the war was over and the vessels returned to the Navy Yard the condition they were in is thus described by Chief Engineer Melville in his official report:

> It is a sad fact that nearly every one (torpedo boats) has had some accidents, and the machinery of some at the close of the war was in a condition which can only be described as horrible, where boilers were burnt, cylinder covers broken, pistons and valves stuck, and everything in bad shape. This condition of affairs seems attributable to two causes; the absence of trained engineering supervision, and the use of the boats for duty to which they were not adapted.

What we fail to comprehend is how a commanding officer, Lieutenant-Commander Kimball, in this case, who could get his boats into such an amateurish condition, could consider himself competent to judge of the professional skill of trained Naval Engineers. It looks very much like the cry of "stop thief" which the runaway raises to effect the escape of himself and his associates.

IT speaks much for the patience of the American citizen that no indignant father or brother has laid the restraining hand on Mr. Richmond Pearson Hobson which the Navy Department should have promptly put forth. Has it lost all sense of perspective in gauging the public behavior of its representatives? It is not long since an official court was called to inquire into the purely private and personal matter of an ensign's courtship, which, if unconventional, was manly and within the bounds of strict propriety. Yet we now have the spectacle of an officer, in whose professional attainments the Department has sufficient confidence to originally select him as the director of the post graduate class at Annapolis, on exhibition throughout the country as a public clown. To be sure Mr. Richmond Pearson Hobson sank the "Merrimac" at Santiago, and the ensign, whose name we do not at the moment recall, probably never did anything more than his duty. But if the Department plays favorites it should not forget that the country, which pays for its Navy, has the right to demand that he who wears the uniform of a United States naval officer shall at least conduct himself as a gentleman.

THE selection of Engineer-in-Chief George W. Melville, U.S.N., for the presidency of the American Society of Mechanical Engineers, is a source of great satisfaction to the marine engineering fraternity throughout the country, both naval and mercantile. His grand qualities as a man, his genius as an engineer, and his record as an naval officer are known wherever ships are known, and there is no gift in the profession or out of it that he could not have by vote of the marine engineers of America.

EDUCATIONAL DEPARTMENT.

CALCULATIONS FOR ENGINEERS—AN AID TO CANDIDATES FOR MARINE PAPERS—IV.

BY DR. WILLIAM FREDERICK DURAND.

Formulæ.

A formula is simply a brief way of denoting a series of mathematical operations. Once understood, the directions given by a formula are much more readily followed than when given in the form of a rule. In fact a formula may be considered as simply a brief or short-hand way of expressing the same directions as are given by the rule in ordinary words. In formulæ, quantities are usually represented by letters, as in the well-known horse power formula:

$$I.H.P. = \frac{2\,p\,L\,A\,N}{33{,}000}$$

In this formula p denotes the mean effective pressure per square inch of piston area, L the length of stroke in feet, A the piston area in square inches, and N the revolutions per minute.

In thus writing letters to represent quantities the sign of multiplication, ×, is usually omitted. Thus in the foregoing the numerator $2\,p\,L\,A\,N$ means the same as $2 \times p \times L \times A \times N$, or that the continued product is to be taken of these five factors. It must be noted, however, that where both factors are numbers the sign for multiplication cannot be omitted. Thus, 23 does not mean 2 × 3, but 20 + 3 or 23.

Division may be expressed by the usual sign, but it is more commonly indicated by writing the dividend as the numerator and the divisor as the denominator of a fraction. Or in general we multiply by putting a factor in the numerator, and divide by putting a factor in the denominator. Thus in the horse power formula the product $2\,p\,L\,A\,N$ is to be divided by 33,000.

As a further illustration, take the formula

$$p = \frac{T\,t}{6\,R}$$

In this formula p is the pressure per square inch in a boiler, T is the tensile strength of the material of the shell, t is the thickness of the plate, and R is the half diameter or radius of the shell. The whole gives the pressure per square inch allowed by U. S. rules on marine boilers. The formula directs us, in order to find the desired pressure, to multiply together T and t and to divide the product by 6 times R; or, in the words of the U. S. rule: "Multiply one-sixth the lowest tensile strength . . . by the thickness . . . and divide by the radius or half diameter." In this formula all dimensions are in inches and the result is the pressure per square inch allowed on the boiler. Thus let $T = 60{,}000$, $t = 1\ 1\text{-}4$ in. and $R = 6$ feet or 72 in. Then:

$$p = \frac{60{,}000 \times 1.25}{6 \times 72} = 174 \textit{ pounds per square inch.}$$

Take again the formula

$$p = \frac{112\,t^2}{L^2}$$

In this formula p is the pressure per square inch allowed on a flat surface of a boiler supported by staybolts, t is the thickness of the plate expressed in sixteenths, and L is the pitch of the bolts, or distance from center to center. The formula thus directs us to multiply 112 by the square of the thickness of the plate in sixteenths, and then to divide the product by the square of the pitch of the bolts. Thus let the thickness be 9-16 in. and pitch be 7 in. Then we have:

$$p = \frac{112 \times 9 \times 9}{7 \times 7} = 185 \textit{ pounds per square inch.}$$

As a last illustration take the following:

$$d = \sqrt{\frac{4\,p\,A}{\pi\,K}} + a$$

Such a formula directs us to multiply together $4 \times p \times A$ and then π or 3.1416 by K, and divide the first product by the second, and then take the square root of the quotient. To this we then add the quantity a, and the result is the value of d as desired. Thus if $p = 160$, $A = 100$, $K = 6{,}000$, and $a = .2$, we have:

$$d = \sqrt{\frac{4 \times 160 \times 100}{3.1416 \times 6{,}000}} + .20 = 1.84 + .20 = 2.04$$

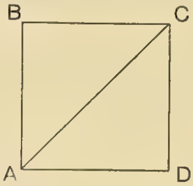
This is a formula for the diameter of piston rod in which d denotes the diameter in inches, p the pressure per square inch of piston area, A the area of piston in square inches, K the safe stress on the material in pounds per square inch of sectional area, and a a small quantity to be added to the result given by the radical.

§ 9. GEOMETRY AND MENSURATION.[8]

[1] Square.

A *square* is a figure, such as $A\,B\,C\,D$, having four sides all equal, and four angles all equal, each being a right angle.

DIAGONAL, $A\,C$. To find the length of a diagonal, $A\,C$, having given a side of the square, as $A\,B$:



Rule—Square the side, multiply by 2, and take the square root;

$$\text{or } A\,C = \sqrt{2\,\overline{A\,B}^2};$$

or *Rule*—Multiply the side by 1.4142.

Example: $A\,B = 16$. Then $A\,C = \sqrt{2 \times 256} = \sqrt{512} = 22.627$,

$$\text{or } A\,C = 16 \times 1.4142 = 22.627.$$

AREA, $A\,B\,C\,D$. To find the area of a square, having given the length of a side, as $A\,B$:

Rule—Square the side, or multiply it by itself;

$$\text{or Area} = \overline{A\,B}^2 = A\,B \times A\,B.$$

Example: $A\,B = 6$. Then area $= 6 \times 6 = 36$.

[8] The following definitions are here given as introductory to this section. Other definitions will be given as the terms are introduced.

An *angle* is formed when two lines, $O\,A$ and $O\,B$, having different directions meet in a point, as O. The angle refers, then, to the difference in direction of the two lines, and its measure is a measure

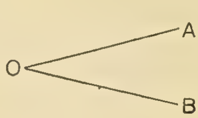


FIG. *a*.

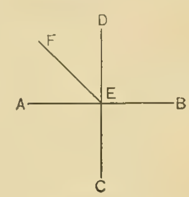


FIG. *b*.

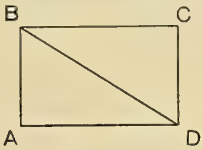
of such difference in direction. An angle is usually denoted by three letters, the one at the apex being placed between the other two. Thus, in *Fig. a* the angle would be called $A\,O\,B$ or $B\,O\,A$.

When a line, $C\,D$, meets another line, $A\,B$, in such way that the four angles at E are all equal, the two lines are said to be *perpendicular* to each other, or, in more common terms, one line is square with the other. An angle such as those formed at E is called a *right angle*.

An angle less than a right angle, as $A\,O\,B$, *Fig. a*, is called an *acute* angle. An angle greater than a right angle, as $F\,E\,B$, *Fig. b* is called an *obtuse* angle.

[2] **Rectangle.**

A *rectangle* is a figure, such as $A\,B\,C\,D$, having four sides, the opposite sides being equal and parallel ($A\,B$



$= D\,C$ and $B\,C = A\,D$), and four angles all equal, each being a right angle.

DIAGONAL, $B\,D$. To find the length of a diagonal, $B\,D$, having given the two sides, as $B\,C$ and $C\,D$:

Rule—Square the two adjacent sides, add, and take the square root;

$$\text{or } B\,D = \sqrt{\overline{B\,C}^2 + \overline{C\,D}^2}.$$

Example: $B\,C = 6$, $B\,D = 8$. Then $B\,D = \sqrt{36 + 64} = \sqrt{100} = 10$.

AREA, $A\,B\,C\,D$. To find the area of a rectangle, having given the two sides, as $A\,B$ and $A\,D$:

Rule—Find the product of the two adjacent sides;

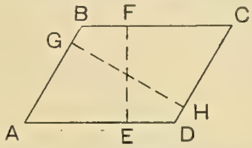
$$\text{or Area} = A\,B \times A\,D.$$

Example: $A\,B = 6$, $A\,D = 8$. Then area $= 6 \times 8 = 48$.

---

[3] **Parallelogram.**

A *parallelogram* is any figure, such as $A\,B\,C\,D$, having four sides and four angles, the opposite sides being equal



and parallel, and the opposite angles being equal.

AREA, $A\,B\,C\,D$. To find the area of a parallelogram, having given a side and the perpendicular distance between this and the side opposite:

Rule—Multiply one side by the perpendicular distance between it and the side opposite;

$$\text{or Area} = A\,D \times E\,F;$$
$$= \text{also } A\,B \times G\,H.$$

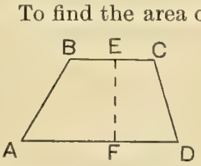
Example: $A\,D = 16$, $E\,F = 9$. Then area $= 9 \times 16 = 144$.

---

[4] **Trapezoid.**

A *trapezoid* is any figure, such as $A\,B\,C\,D$, having four sides and four angles, two of the sides, as $B\,C$ and $A\,D$, being parallel.

AREA, $A\,B\,C\,D$. To find the area of a trapezoid, hav-



ing given the parallel sides and the perpendicular distance between them:

Rule—Multiply the half sum of the parallel sides by the perpendicular distance between them,

$$\text{or Area} = \left(\frac{B\,C + A\,D}{2}\right) \times E\,F.$$

Example: $B\,C = 10$, $A\,D = 16$, $E\,F = 8$. Then area $= \left(\frac{10 + 16}{2}\right) \times 8 = 104$.

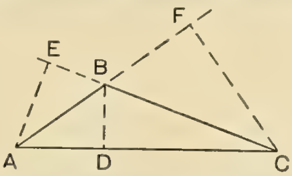
---

[5] **Triangle.**

A *triangle* is any figure, such as $A\,B\,C$, having three sides and three angles. In a triangle placed as in the figure, $A\,C$ is called the *base*, and $B\,D$—the perpendicular distance from B to $A\,C$—is called the *altitude*.

ANY SIDE, $A\,B$. To find the length of any side, having given the triangle complete:

Rule—Square the other two sides and add, and according as the angle between them is greater or less than 90 degrees, add or subtract twice the product of one of



these sides by the projection[9] of the other upon it. Then take the square root of the result thus found;

$$\text{or } A\,B = \sqrt{\overline{A\,C}^2 + \overline{B\,C}^2 - 2\,A\,C \times D\,C.}$$

$$\text{Similarly } B\,C = \sqrt{\overline{A\,B}^2 + \overline{A\,C}^2 - 2\,A\,C \times A\,D,}$$

$$\text{and } A\,C = \sqrt{\overline{A\,B}^2 + \overline{B\,C}^2 + 2\,B\,C \times B\,E.}$$

Example: $A\,C = 12$, $B\,C = 9$, $D\,C = 8$. Then $A\,B = \sqrt{144 + 81 - 2 \times 12 \times 8} = \sqrt{33} = 5.745$.

AREA. To find the area of a triangle, having given the triangle complete, or any side and its perpendicular distance from the opposite vertex:

Rule—Multiply any side by the perpendicular distance from the opposite vertex to such side (produced, if necessary, to meet the perpendicular), and take half the product thus found;

or take half the product of the base by the altitude;

$$\text{or Area} = \tfrac{1}{2}\,(A\,C \times B\,D),$$
$$= \tfrac{1}{2}\,(B\,C \times A\,E),$$
$$= \tfrac{1}{2}\,(A\,B \times C\,F).$$

Example: $A\,C = 120$, $B\,D = 32$. Then area $= \tfrac{1}{2}\,(120 \times 32) = 1{,}920$.

---

9 Let $B\,D$ be drawn perpendicular to $A\,C$. Then $D\,C$ is called the *projection* of $B\,C$ upon $A\,C$. Similarly $A\,D$ is the projection of $A\,B$ upon $A\,C$, $A\,F$ the projection of $A\,C$ upon $A\,B$ produced, and $E\,C$ the projection of $A\,C$ upon $B\,C$ produced.

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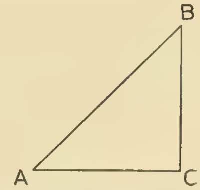
[6] **Right-Angled Triangle.**

In a *right-angled triangle* one of the angles, as C, is a right angle. The side opposite is called the *hypothenuse*.



HYPOTHENUSE, $A\,B$. To find the length of the hypothenuse, having given the other two sides:

Rule—Square the other two sides and add, and take the square root of the sum;

$$\text{or } A\,B = \sqrt{\overline{A\,C}^2 + \overline{B\,C}^2}.$$

Example: $A\,C = 9$, $B\,C = 12$. Then $A\,B = \sqrt{81 + 144} = \sqrt{225} = 15$.

SIDE. $A\,C$ or $B\,C$. To find the length of one of the sides about the right angle, having given the hypothenuse and the other side:

Rule—Square the hypothenuse and the given side. Subtract the squares, and take the square root of the difference;

$$\text{or } A\,C = \sqrt{\overline{A\,B}^2 - \overline{B\,C}^2}.$$

Example: $A\,B = 15$, $B\,C = 12$. Then $A\,C = \sqrt{225 - 144} = \sqrt{81} = 9$.

AREA, $A\,B\,C$. To find the area of a right-angled triangle, having given the two sides about the right angle:

Rule—Multiply together the two sides about the right angle, and take half their product;

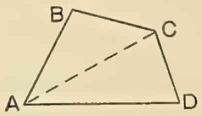
$$\text{or Area} = \tfrac{1}{2}\,(A\,C \times B\,C).$$

Example: $AC = 9$, $BC = 12$. Then area $= \frac{1}{2}(9 \times 12) = 54$.

These rules are special cases of those for the general triangle, as in [5].

[7] Trapezium.

A *trapezium* is a figure, such as *A B C D*, having four angles and four sides, no two of the latter being parallel.

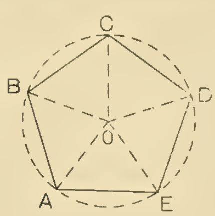


AREA, *A B C D*. To find the area of a trapezium, having given the figure complete:

Rule—Divide the trapezium into two triangles, and proceed with each separately, and then add.

[8] Regular Polygons.

A *regular polygon* is a figure, such as *A B C D E*, having any number of equal sides and a like number of equal angles. They are named as follows:



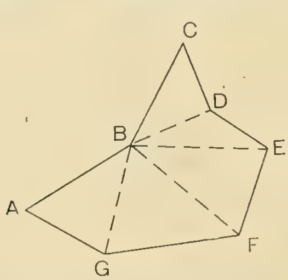
Number of Sides.	*Names.*
3	Triangle
4	Square
5	Pentagon
6	Hexagon
7	Heptagon
8	Octagon
9	Nonagon
10	Decagon

AREA. To find the area of any regular polygon; as *A B C D E*, having given the figure complete:

Rule—Divide the polygon into as many triangles as there are sides, the apexes all being at the center. Find the area of one of these, and multiply by the number of sides.

[9] Irregular Figure.

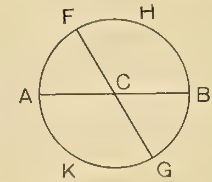
AREA. To find the area of a figure, such as *A B C D E F G*, having given the figure complete:



Rule—Divide into triangles in any convenient way; proceed with each separately, and add the results.

[10] Circle.

A *circle* is a figure bounded by a curved line, every point of which is equally distant from a point within, called the center. The distance across from one side to the other through the center is called the *diameter* (see *A B* or *F G*). The diameter is usually represented by *D*. The distance from the center to the curved boundary line is called the *radius*, and is plainly one-half the diameter (see *A C*, *F C*, etc.). The radius is usually represented by *r*. The curved boundary line, *A F H B*



G K A, is called the *circumference*. Any part of the circumference, as *A F*, *F H*. etc., is called an *arc*.

CIRCUMFERENCE. To find the circumference, having given the diameter:

Rule—Multiply the diameter by 3.1416, or more exactly by 3.1415927, or less exactly by $\frac{22}{7}$. This ratio is frequently denoted by the symbol π,

or Circumference $= 3.1416 \times$ Diameter $= \pi D$.

Example: Diameter $= 11$. Then circumference $= 11 \times 3.1416 = 34.5576$.

DIAMETER. To find the diameter, having given the circumference:

Rule—Divide the circumference by 3.1416, or more exactly by 3.1415927, or less exactly by $\frac{22}{7}$,

or Diameter = Circumference $\div$ 3.1416,
or Diameter = Circumference $\times$ .31831.

Example: Circumference $= 48.7$. Then diameter $= 48.7 \div 3.1416 = 15.50 +$

AREA, *A H B K*. To find the area of a circle, having given the diameter or the radius:

Rule—Multiply the square of the diameter by .7854 or $\frac{3.1416}{4}$,

or multiply the square of the radius by 3.1416,

or find half the product of the radius by the circumference,

$$\text{or Area} = .7854 \times (\text{Diameter})^2 = \frac{\pi D^2}{4},$$
$$= 3.1416 \times (\text{Radius})^2 = \pi r^2,$$
$$= \tfrac{1}{2}(\text{Radius} \times \text{Circumference}).$$

Example: Diameter $= 10$. Then area $= .7854 \times 100 = 78.54$.

LENGTH OF ARC. To find the length of an arc, as *A F*, having given the corresponding number of degrees and the circumference or diameter:

Rule—Divide the circumference by 360, and multiply by the number of degrees in the arc;

or multiply the number of degrees by .008727 and the product by the diameter,

$$\text{or Length } AF = \frac{\text{Circumference}}{360} \times (\text{Number of Degrees}),$$

or Length AF = (Number of Degrees) $\times$ .008727 $\times$ Diameter.

Example: Find the length of an arc of 60 degrees in a circle whose diameter is 20.

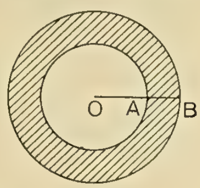
Length $= 60 \times .008727 \times 20 = 10.4724$.

[11] Circular Ring or Annulus.

The surface lying between two circles, as shown by the shaded part of the figure, is called a *circular ring* or *annulus*.

AREA. To find the area of a circular ring, having given the radii of the two circles:

Rule—Find the difference between the areas of the two circles,

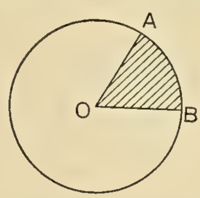


or Area $= 3.1416\ \overline{OB}^2 - 3.1416\ \overline{OA}^2 = 3.1416\ (\overline{OB}^2 - \overline{OA}^2)$.

[12] **Sector of Circle.**

The surface lying between two radii and the corresponding part of the circumference, as shown by the shaded part of the figure, is called the *sector* of a circle, or a circular *sector.*

Area, *A B O.* To find the area of the sector of a circle,



having given the corresponding number of degrees and the diameter:

Rule—Find the area of the entire circle, divide by 360, and multiply by the number of degrees in the sector;

or Area $= \frac{\text{Area of Circle}}{360}$ (Number of Degrees in Sector);

or, by proportion, 360° : Number of Degrees in Sector : : Area of Circle : Area of Sector;

or, otherwise, find half the product of the arc by the radius,

or Area $= \frac{1}{2}\ (O\ A \times A\ B)$.

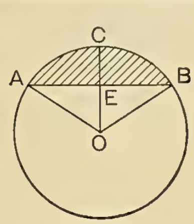
Example: Find the area of a sector of 60 deg. in a circle whose radius is 10.

Area of entire circle = 78.54,

hence Area $= \frac{78.54}{360} \times 60 = \frac{78.54}{6} = 13.09$.

[13] **Segment of Circle.**

A line, such as *A B*, cutting across a circle is called a *chord.* A part of the surface of a circle between a chord



and the circumference, as shown by the shaded part of the figure, is called a *segment of a circle.*

Area, *A C B.* To find the area of the segment of a circle, having given the angle, *A O B*, and the diameter or radius of the circle:

Rule—Find the area of the sector, *O A C B*, as in [12], and of the triangle, *O A B*, as in [5], and subtract the latter from the former;

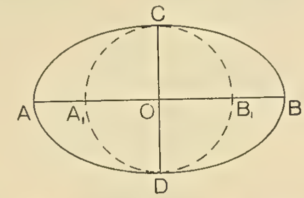
or Area $= \frac{1}{2}\ (A\ C\ B \times O\ A - O\ E \times A\ B)$.

Example: $O\ A = 10$, $O\ E = 5$, $A\ B = 17.32$, $A\ C\ B = 20.944$,

then Area $= \frac{1}{2}\ (20.944 \times 10 - 5 \times 17.32) = 61.42$.

[14] **Ellipse.**

If the surface of a circle, as shown by the dotted line, be uniformly stretched in one direction (horizontal in the figure) until the diameter, $A_1\ B_1$, becomes equal to *A B*, the circumference will be changed into a curved



line, *A C B D*, and the figure thus formed is called an *ellipse.* The two lines, *A B* and *C D*, are called the *diameters* of the ellipse.

Area, *A C B D.* To find the area of an ellipse, having given the two diameters:

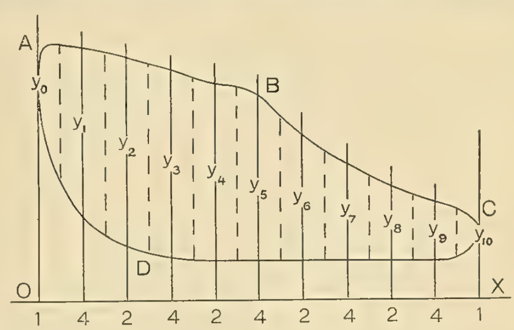
Rule—Multiply the product of the two half diameters by 3.1416,

or Area $= 3.1416 \times O\ C \times O\ B$.

Example: $O\ C = 5$, $O\ B = 8$. Then area $= 3.1416 \times 5 \times 8 = 125.664$.

[15] **Figures With an Irregular Contour.**

To find Area, *A B C D*, representing, for example, an indicator card. This cannot be done with absolute ex-



actness, but there are a number of rules for finding the approximate area as closely as we may desire.

Divide the base *O X* into any appropriate number of intervals, usually 10 for an indicator card, and draw lines across the card as shown.

Rule (1)—(*Trapezoidal*). Measure the successive ordinates or breadths on the full lines and from their sum subtract one-half the sum of the end ordinates. Multiply the remainder by the length of the internal or by $O\ X \div 10$, and the product is the area desired; or calling the breadth y_0, y_1, y_2, etc., we have by formula in this case.

$$\text{Area} = \frac{O\ X}{10}\left(\tfrac{1}{2}\ y_0 + y_1 + y_2 + y_3 + y_4 + y_5 + y_6 + y_7 + y_8 + y_9 + \tfrac{1}{2}\ y_{10}\right)$$

As a slightly different and preferable mode of procedure with this rule we may measure the breadths midway between the lines of division as indicated by the dotted lines. Their sum, without modification, is then multiplied by the length of the interval as before.

Any number of spaces as desired may be employed with this rule.

Rule (2)—(*Simpson's or Parabolic*). Measure the ordinates as before.

Take: Once the first and last. Four times every other one beginning with the second. Twice the remaining.

(These multipliers are shown in the figure below the line *O X.*)

Add the products and multiply by one-third the interval, or in this case by $O\ X \div 30$; or by formula in this case:

$$\text{Area} = \frac{O\ X}{30}\left(y_0 + 4y_1 + 2y_2 + 4y_3 + 2y_4 + 4y_5 + 2y_6 + 4y_7 + 2y_8 + 4y_9 + y_{10}\right)$$

With this rule the number of spaces must be even.

Rule (3)—(*Durand's*). Measure the ordinates as before. To their sum add one-twelfth the sum of those next the end and subtract seven-twelfths of those at the end. Multiply the result by the interval and the product is the area desired;

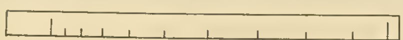
or by formula in this case:

$$\text{Area} = \frac{OX}{10}\left\{\begin{array}{l} y_0+y_1+y_2+y_3+y_4+y_5+y_6+y_7+y_8+y_9+y_{10} \\ +\frac{1}{12}(y_1+y_9) \\ -\frac{7}{12}(y_0+y_{10}) \end{array}\right\}$$

With this rule any number of spaces as desired may be employed.

The measurement and addition of ordinates as in rules (1) and (3) may be quickly effected by means of a strip of paper on which their lengths are marked off directly from the card and without the use of a scale, joining the end of one to the beginning of the next and thus effecting mechanically the addition desired.

To a reduced scale the strip when marked would resemble *Fig. 16*, the ordinates being as indicated in the margin. The sum total is then directly found by means of a scale.



Example: Suppose that the ordinates of an irregular area at one-half inch intervals are found by measurement to be as follows in column (1):

	(1) *Ordinates.*	(2) *Multipliers.*	(3) *Products.*
y_0	.44	1	.44
y_1	1.42	4	5.68
y_2	1.61	2	3.22
y_3	1.56	4	6.24
y_4	1.51	2	3.02
y_5	1.46	4	5.84
y_6	1.20	2	2.40
y_7	.95	4	3.80
y_8	.71	2	1.42
y_9	.49	4	1.96
y_{10}	.18	1	.18
Sums	11.53		34.20

We then have, according to rule (1):

Sum of ordinates = 11.53
½ sum of ends... = .31

Difference... = 11.22
Interval .... = .5

Area = Product = 5.61 square inches.

According to rule (2), we have the multipliers and products as given in columns (2) and (3).

We then have:

Area = $\frac{1}{3} \times .5 \times 34.20$ = 5.70 square inches.

According to rule (3), we have from column (1):

Sum of ordinates ..... = 11.53
$\frac{1}{12}$ sum of next to ends = .16

Sum .... = 11.67
$\frac{7}{12}$ sum of ends .... = .36

Difference........ = 11.31

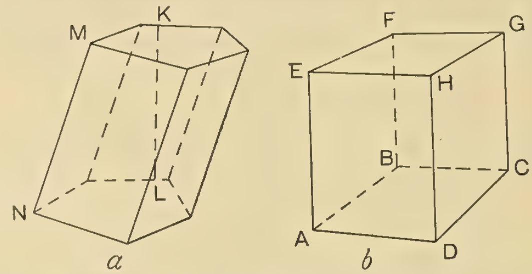
Area = $.5 \times 11.31$ = 5.66 square inches.

Areas of irregular figures, such as indicator cards, etc., may also be found by an instrument called the *planimeter*. In this instrument a pointer is traced around the contour of the figure, while the area is read off from a wheel, which is given appropriate motion by the movement of the pointer. Such instruments, with instructions for use, may usually be obtained from the makers of steam-engine indicators or from dealers in mathematical instruments.

[16] **Prism.**

A *prism* is a solid body, bounded by two equal and parallel ends and by three or more sides or faces, forming at their junction a like number of parallel edges.

When the sides are perpendicular to the ends, and are therefore all rectangles, the solid is known as a *right prism.*



When the sides and ends are all squares, the solid is known as a *cube.*

SURFACE. To find the surface of any prism, having given the figure complete:

Rule—Find the area of the base (or top) by such of the preceding rules as may be appropriate. For the side or *lateral* surface, multiply the *perimeter* or boundary of the base by the perpendicular or shortest distance between any two corresponding lines of the base and top (as $K L$ in *Fig. a*).

VOLUME. To find the volume of any prism, having given the base and altitude:

Rule—Multiply the area of the base or end by the altitude or perpendicular distance between the two ends.

RIGHT PRISM. In a right prism the preceding general rules hold, but the lateral faces are all rectangles, and the perpendicular distance between their ends, as $K L$; the length of an edge, as $M N$, and the altitude or perpendicular distance between the ends, all three become equal.

RIGHT PRISM, WITH RECTANGULAR BASE. In a solid of this character (see *Fig. b*) the preceding rules still hold, but the sides and ends are all rectangles, and the rules may be simplified as follows:

For the LATERAL SURFACE:

Rule—Multiply the perimeter of the base by the altitude,

or Lateral Surface = Length $A\,B\,C\,D \times A\,E$.

For the VOLUME:

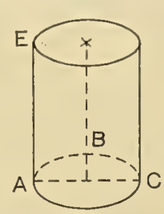
Rule—Multiply together the length and breadth of base and the product by the altitude,

or Volume = $A\,B \times A\,D \times A\,E$.

Example: $A\,B = 8$, $A\,D = 6$, $A\,E = 10$. Then lateral surface = $(8 + 6 + 8 + 6) \times 10 = 28 \times 10 = 280$, and volume = $8 \times 6 \times 10 = 480$.

[17] **Cylinder.**

A solid with equal circles for base and top, and with a curved lateral surface, is called a *cylinder*. If the center of the top is vertically over the center of the base, the solid is called a *right cylinder.*



LATERAL SURFACE OF RIGHT CYLINDER. To find the lateral surface of a right cylinder, having given the diameter of base and the altitude:

Rule—Multiply the circumference of the base by the altitude,

or Lateral Surface = Circumference $A\ B\ C\ D \times A\ E = 3.1416 \times A\ C \times A\ E$.

Example: $A\ C = 10$, $A\ E = 20$. Then lateral surface $= 3.1416 \times 10 \times 20 = 628.32$.

VOLUME OF RIGHT CYLINDER. To find the volume of a right cylinder, having given the base and altitude:

Rule—Multiply the area of the base by the altitude,

or Volume = Area $A\ B\ C\ D \times A\ E = .7854\ \overline{A\ C}^2 \times A\ E$.

Example: $A\ C = 10$, $A\ E = 20$. Then volume $= .7854 \times 100 \times 20 = 1{,}570.8$.

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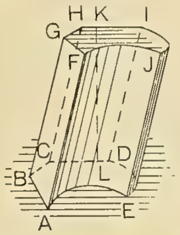
[18] Any Solid with a Constant Section Parallel to the Base, Either Right or Oblique.

Such a solid is the general case of which the prism and cylinder are but special examples. The rules will therefore be similar to those of [16] and [17].

SURFACE. To find the surface of such a solid, having given the figure complete:

Rule—Find the area of the base (or top) by such of the preceding methods as may be appropriate. For the side or lateral surface, multiply the *perimeter* or boundary of the base by the perpendicular or shortest distance



between any two corresponding lines of the base and top (as $K\ L$ in the figure);

or Lateral Surface = Length $A\ B\ C\ D\ E\ A \times K\ L$.

VOLUME. To find the volume of such a solid, having given the figure complete:

Rule—Multiply the area of the base by the perpendicular distance between the base and the top,

or Volume = Area of Base $\times$ Vertical Altitude.

Example: Area of base = 120, altitude = 40. Then volume $= 40 \times 120 = 4{,}800$.

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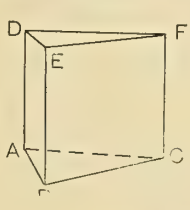
[19] Wedge.

A right prism with a triangular base, having two sides equal, as $A\ C$ and $B\ C$, is called a *wedge*.



To find the SURFACE or VOLUME, use the same rules as in [16].

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[20] Right Pyramid.

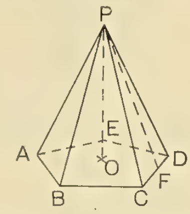
A solid, bounded by a base and by triangular sides meeting in a point or *apex*, as *P*, is called a *pyramid*. If the base is a regular polygon [8] and the apex is vertically over the center of the base, the solid is called a *right pyramid* (see figure).

LATERAL SURFACE. To find the lateral surface of a right pyramid, having given the figure complete:

Rule—Take one-half the product of the perimeter or boundary of the base by the perpendicular or shortest distance from the apex to one of the sides of the base, as $P\ F$,

$$\text{or Lateral Surface} = \frac{\text{Length } A\ B\ C\ D\ E\ A \times P\ F}{2}.$$

VOLUME. To find the volume of a right pyramid, having given the base and altitude:



Rule—Take one-third of the product of the area of the base by the altitude, as $P\ O$,

$$\text{or Volume} = \frac{(\text{Area of Base}) \times (\text{Altitude})}{3}.$$

Example: Area of base = 180, altitude = 16. Then volume $= \frac{180 \times 16}{3} = 960$.

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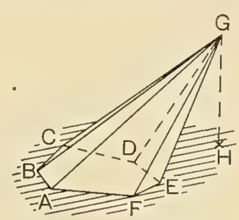
[21] General Pyramid.

For definition see [20].

LATERAL SURFACE. To find the lateral surface of any pyramid, having given the figure complete:

Rule—The surface will consist of a series of triangles, similar or not, according to the nature of the pyramid.



These must be computed according to the rules for triangles and the results added.

VOLUME. To find the volume of any pyramid, having given the base and altitude:

Rule—Take one-third the product of the area of the base by the vertical altitude, as $G\ H$,

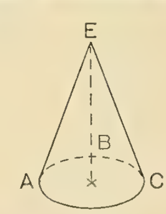
$$\text{or Volume} = \frac{(\text{Area of Base}) \times G\ H}{3}.$$

Example: Area of base = 48, $G\ H = 18$. Then volume $= \frac{48 \times 18}{3} = 288$.

---

[22] Right Circular Cone.

Any solid having a base with curved or irregular boundary, an apex, and straight sides, is called a *cone* in general. If the base is a circle and the apex is vertically over the center, the solid is called a *right circular cone* (see figure).



LATERAL SURFACE. To find the lateral surface of a right circular cone, having given the base and the slant height:

Rule—Take one-half the product of the circumference of the base by the slant height,

$$\text{or Lateral Surface} = \frac{\text{Circumference } A\ B\ C\ D\ A \times A\ E}{2}.$$

Example: Diameter = 10, $A\ E = 20$. Then surface $= \frac{3.1416 \times 10 \times 20}{2} = 314.16$.

VOLUME. To find the volume of a cone, as in *Fig. 23*, having given the base and altitude:

Rule—Take one-third the product of the area of the base by the altitude,

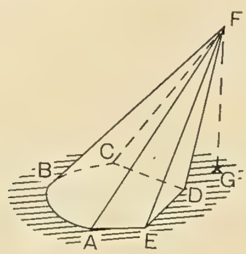
$$\text{or Volume} = \frac{\text{Area of Base } A\ B\ C\ D \times E\ F}{3}.$$

Example: Diameter = 8, $E\ F = 15$. Then volume $= \frac{.7854 \times 64 \times 15}{3} = 251.328$.

[23] **General Cone.**

For definition see [22].

VOLUME. To find the volume of any cone, having given the base and vertical altitude:



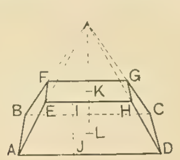
Rule—Take one-third the product of the area of the base by the vertical altitude, as $F\ G$,

$$\text{or Volume} = \frac{\text{Area of Base} \times F\ G}{3}.$$

Example: Area of base = 240, $F\ G = 40$. Then volume $= \frac{240 \times 40}{3} = 3{,}200$.

[24] **Frustrum of Right Pyramid.**

The solid contained between the base of a pyramid



and a parallel plane, as $E\ F\ G\ H$, is called the *frustrum* of a pyramid.

LATERAL SURFACE. To find the lateral surface of a frustrum of a right pyramid, having given the figure complete:

Rule—Add the *perimeters* or boundaries of the base and top, and multiply the sum by one-half the perpendicular or shortest distance between two corresponding lines of the base and top, as $I\ J$,

$$\text{or Lat. Surface} = \frac{(\text{Length } A\ B\ C\ D + \text{Length } E\ F\ G\ H) \times I\ J}{2}$$

Example: $A\ B = 10$, $A\ D = 12$, $E\ F = 6$, $E\ H = 7.2$, $I\ J = 5$. Then surface $= \frac{(44 + 26.4) \times 5}{2} = 176$.

VOLUME. To find the volume of a frustrum of a right pyramid, having given the base and top and vertical distance between them:

Rule—Add together the areas of the base and top and the square root of their product, and multiply the sum by one-third the vertical altitude, as $K\ L$,

$$\text{or Vol.} = \frac{(A\ B\ C\ D + E\ F\ G\ H + \sqrt{A\ B\ C\ D \times E\ F\ G\ H}) \times K\ L}{3}$$

Example: Area $A\ B\ C\ D = 100$, area $E\ F\ G\ H = 42$, $K\ L = 12$. Then volume $= \frac{(100 + 42 + \sqrt{4{,}200}) \times 12}{3} = 827.2$.

[25] **Frustrum of General Pyramid, as [21].**

To find the LATERAL SURFACE:

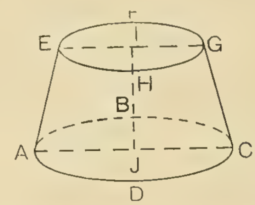
Rule—The surface will consist of a number of trapezoids, similar or not, according to the nature of the frustrum. These must be computed according to [4] and the results added.

To find the VOLUME:

Rule—Same as for [24].

[26] **Frustrum of Right Cone.**

The solid contained between the base of a cone and a



parallel plane, as $E\ F\ G\ H$, is called the *frustrum of a cone.*

LATERAL SURFACE. To find the lateral surface of a frustrum of a right cone, having given the base and top and slant height:

Rule—Add the circumference of the base and top, and multiply the sum by one-half the slant height, as $A\ E$,

$$\text{or Lat. Surface} = \frac{(\text{Cir. } A\ B\ C\ D + \text{Cir. } E\ F\ G\ H) \times A\ E}{2}.$$

Example: Diameter $A\ C = 12$, diameter $E\ G = 10$, $A\ E = 8$. Then surface $= \frac{(3.1416 \times 12 + 3.1416 \times 10) \times 8}{2} = 276.47$.

VOLUME. To find the volume of a frustrum of a right cone, having given the base and top and vertical altitude:

Rule—Same as for [24].

Or in slightly different form, we have the following:

Rule—Add together the square of the upper diameter, the square of the lower diameter, and their product, and multiply the sum by the vertical altitude and by the number .2618,

$$\text{or Volume} = .2618\ I\ J\ (\overline{E\ G}^2 + \overline{A\ C}^2 + E\ G \times A\ C).$$

Example: $E\ G = 6$, $A\ C = 8$, $I\ J = 4$. Then volume $= .2618 \times 4\ (36 + 64 + 48) = 155$.

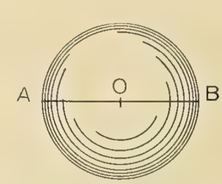
[27] **Frustrum of General Cone, as [23].**

To find the VOLUME:

Rule—Same as for [24].

[28] **Sphere.**

A solid inclosed by a curved surface, every point of which is equally distant from a point within called the center, is called a *sphere*. The distance, $A\ B$, from one



side to the other through the center is called the *diameter*. The distance, $A\ O$, from the surface to the center is called the *radius*, and is plainly one-half the diameter.

SURFACE. To find the surface of a sphere, having given the diameter:

Rule—Square the diameter and multiply by 3.1416, or Surface = 3.1416 (Diameter)^2.

Example: Diameter = 20. Then surface = 3.1416 × 400 = 1,256.64.

VOLUME. To find the volume of a sphere, having given the diameter or radius:

Rule—Multiply the cube of the radius by 4.1888, or multiply the cube of the diameter by .5236,

$$\text{or Volume} = 4.1888\ \overline{A\ O}^3.$$

$$\text{or Volume} = .5236\ \overline{A\ B}^3.$$

[29] **Volume of Irregular Shape.**

Volumes of irregular shape in which the areas of a series of equally-spaced sections may be found.

Rule—Find the areas of a series of equally-spaced cross sections and treat them by the rules given in [15], using areas for ordinates. The result will give the volume desired.

Examples:

(1) Find the volume of an irregular box, 12 feet long; area of one end, 6 square feet; of the other, 15 square feet, and of a section midway between, 10 square feet. The interval is 6 feet.

Then, with Simpson's rule,

Volume = $\frac{6}{3} \times (6 + 4 \times 10 + 15) = 122$ cubic feet.

(2) Find the volume of a coal bunker, 20 feet long, having cross sections every 4 feet, as follows:

Taking rule (3), in [15], we find the result as below:

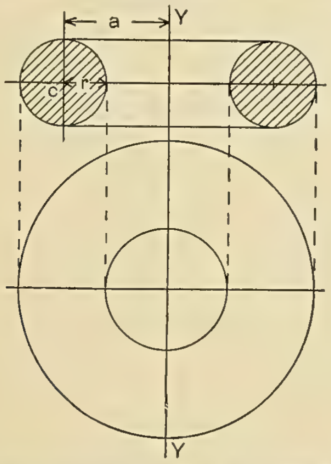
	Square Feet.	
		297
A_0 =	40	8.3
A_1 =	46	———
A_2 =	50	305.3
A_3 =	52	55.4
A_4 =	54	———
A_5 =	55	249.9
	———	4
		———
		999.6; or, say, 1,000 cubic feet.

[30] **Volume Generated by Any Area Revolving About an Axis.**

Example: TORUS OR RING.

SURFACE. To find the surface of a ring, having given the necessary dimensions:

Rule—Multiply the length of the generating line by



the length of the path followed by its center of gravity.

Example, as in the figure.

The length of the generating line is $2\pi r$.

The length of the path of the center, C, is $2\pi a$.

The surface is $\therefore\ 2\pi r \times 2\pi a = 4\pi^2 a r$.

VOLUME. To find the volume of a ring, having given the necessary dimensions:

Rule—Multiply the generating area by the length of the path traveled by its center of gravity.

Example, as in the figure.

The generating area is πr^2.

The length of the path of the center, C, is $2\pi a$.

The volume is $\therefore\ 2\pi^2 a r^2$.

HELPS FOR CANDIDATES FOR MARINE ENGINEERS' LICENSES—FUELS—I.

BY DR. WILLIAM FREDERICK DURAND.

§ 1 COAL.

[1] COMPOSITION AND GENERAL PROPERTIES. The principal fuel for engineering purposes is coal. It consists of the following chief substances:

(A) *Uncrystallized Carbon.*

(B) *Volatile Hydrocarbons.* Hydrocarbons are chemical substances formed of carbon and hydrogen in certain proportions. They often become partially oxidized[1] by the union of part of their hydrogen with oxygen, in the same proportion as in water. Upon the application of heat to the coal they escape in the form of gas, and are hence said to be *volatile.*

(C) *Nitrogen and Oxygen.* These gases, the constituents of air, are also found, the latter in addition to the amount joined to the hydrogen as above referred to.

(D) *Sulphur.* This is found in small amounts, chiefly as a part of the mineral known as *iron pyrites*[2]. The proportion of sulphur is rarely above three per cent and usually much less.

(E) *Ash.* This consists of the earthy and incombustible substances present as impurities in the coal.

Coal may be roughly divided into two chief varieties, *Anthracite* and *Bituminous*, with intermediate grades, *Semi-anthracite* and *Semi-bituminous* occupying the general middle ground between the two. In the present chapter we shall frequently use the terms *anthracite* and *bituminous* as denoting the general division into the two chief varieties, as above noted.

Anthracite coal is sold commercially in hard, compact lumps, showing a shiny, smooth surface when first broken. Bituminous coal is relatively soft and is sold commercially in lumps of irregular size. It crumbles easily, showing often a rather dull surface when broken.

In anthracite coal the proportion of volatile matter varies from 3 to 10 per cent; in semi-anthracite and semi-bituminous, from 10 to 20 per cent, and in bituminous, from 20 to 50 per cent. The amount of ash in good coal should not exceed from 8 to 10 per cent, while occasionally it falls as low as 5 per cent. Anthracite coal is graded commercially, according to size, the chief terms being the following, in the order of increasing size: *Buckwheat, pea, chestnut, stone, egg, broken* and *lump.*

[2] COMBUSTION.

Combustion means simply the chemical union of a substance with oxygen. The oxygen is furnished by the air which contains oxygen and nitrogen. These in air are not in chemical union, but simply as a mixture, in the proportion by weight of twenty-three parts oxygen to seventy-seven parts nitrogen in 100 parts of air. When bodies enter into combustion, or into combustion with oxygen, heat is set free, and the products formed by the combustion are very much hotter than the original fuel and oxygen.

The manner in which coal burns, or enters into combustion, depends upon its composition and upon the nature of the fire and the supply of air. The elements available for the liberation of heat are the carbon and the hydrogen. Small quantities of sulphur are frequently present, but the amount is so small and the heating power so feeble that its influence may be neglected. A pound of pure carbon requires for its complete combustion, 2 2-3 pounds of oxygen, and the result is 3 2-3 pounds of *carbonic acid* or *carbon dioxide* in the form of gas. The total amount of heat set free in this operation is about 14,500 heat units. Now, since the proportion of oxygen in the air is about 23

[1] Oxidised means united with oxygen.

[2] *Iron pyrites* is a mineral formed of iron and sulphur in the proportion of 46.7 parts of iron to 53.3 of sulphur.

per cent, the number of pounds of air required per pound of carbon will be 2 2-3÷.23, or 2.66÷.23, or about 12. Similarly a pound of pure hydrogen requires for its complete combustion, 8 pounds of oxygen, and the result is 9 pounds of water vapor. The total amount of heat set free in this operation is about 62,000 heat units. In the same way as above, it follows that the combustion of a pound of hydrogen will require the presence of 8÷.23, or about 35 pounds of air. The amount of hydrogen, however, is usually small, and allowing for the ash the amount of air necessary to barely furnish the oxygen required for one pound of fuel is about 12, or substantially the same as for one pound of carbon. In practice, however, it is found that this would be insufficient to maintain the draft, nor could we expect that the air would be so distributed as to give exactly the right amount of oxygen at the right place. It is, therefore, necessary practically, to provide a large excess of air and the amount actually passing into the furnaces is usually not less than 18 or 20 pounds per pound of coal, and may even considerably exceed this amount.

Let us now consider the process of combustion with bituminous or semi-bituminous coal. When such coal is put on the fire the first result is not a combustion of the carbon, but a distillation or driving off of the hydrocarbons in the form of gas, and until this operation is nearly completed there will be little or no combustion of the carbon. During this first operation of distillation, heat is absorbed by the fresh coal from the remainder of the fire for the liberation of these gases which are substantially the same as those forming ordinary illuminating gas. After these gases are liberated from the coal they rise into the furnace and combustion chamber. Here, if they meet with a suitable supply of air at a proper temperature, they will be burned, both carbon and hydrogen, and will thus set free all the heat which is obtainable from them. If the air is insufficient in amount the gases will be only partly consumed, the oxygen uniting most readily with the hydrogen and leaving the carbon in fine particles to form *smoke* or *soot*, according as they float away with the products of combustion, or become closely packed together on some of the surfaces of the boiler. If the air is not sufficiently hot likewise, we may have a partial combustion resulting in burning the hydrogen into water vapor and in setting the carbon free as smoke or soot as before. If, however, the temperature is too low the gases may become chilled and pass off as a whole unburnt, thus carrying away not only their own heat of combustion, but also the heat which was absorbed for their liberation. If, on the other hand hydrocarbon gases are subjected to a very high temperature before being mixed with the air, they will become more or less brokn up into free hydrogen and carbon in fine particles. If these are kept at a temperature high enough for ignition and are supplied with oxygen, they will burn; but if they fall below the proper temperature they pass off unburnt, the carbon constituting smoke or soot, as before. Smoke is therefore the sign of a fuel containing hydrocarbons, and of a more or less imperfect combustion. The actual amount of fuel lost in ordinary smoke is, however, very small; so small that it is usually considered as having no significant influence on the question of economy. Hence, smoke prevention is often considered as hardly worth special effort, so far as the saving of fuel alone is concerned. There may be other losses, however, in connection with the general condition of which smoke is an indication, and any mode of design and of general operation which reduces the smoke formation will usually tend toward economy of combustion.

We have already seen that the conditions for burning the hydrocarbon gas are high temperature and an air supply above the grates and in the combustion chamber. We have here, then, one of the reasons for providing openings for the proper admission of air above the grates as well as underneath.

Let us now return to the residue left on the grates after the escape of the hydrocarbon gases. During this part of the operation certain kinds of bituminous coal swell up and cake more or less firmly together on the grate. Such are called *caking* coals. The swelling up is due to the formation of gas in the midst of the coal and to its efforts to escape, while the caking is due to a partial softening or melting of the substance under heat as the hydrocarbons are set free. Other kinds of bituminous coal undergo little change in their external form, while still others break up into small particles or grains. Those latter varieties are called *non-caking* or *free-burning* coals. In any case the residue, after the hydrocarbons are set free, is called coke and consists of nearly pure carbon with ash.

As we have already seen the carbon burns by uniting with oxygen, and this must take place at the burning lump itself. Hence, it is necessary that the air should penetrate thoroughly all parts of the fire, and to this end it is brought in, in part at least, under the grate and by the draft pressure is forced upward through the mass of burning coal. If the fire is rather thick the operation proceeds in the following way. The carbon and oxygen first unite in complete combustion, 1 pound of carbon to 2 2-3 pounds of oxygen, and the product, carbon dioxide, proceeds upward through the fire. As this gas comes in contact, however, with the cooler coal in the midst or near the top of the bed of fuel it absorbs some of the carbon and becomes changed to a combination in the proportion of 1 pound of carbon to 1 1-3 pounds of oxygen. This gas is called *carbon monoxide*. In this operation also is absorbed back again more than two-thirds of the heat which the first combustion had liberated. If the gas should escape unburnt, a serious loss would result, as only about 4,450 heat units or less than one-third of the heat available in the carbon would have been liberated. If, however, the gas finds air above the grate and a suitable temperature, the carbon which was absorbed is burnt out again and the corresponding heat is given back, so that the final result is the completed combustion of the carbon and the liberation of all the heat possible. The formation of carbon monoxide in this way shows again the need of admitting air over the grate, as well as underneath. This gas burns with the peculiar blue flame so often seen, especially after a fresh firing with anthracite coal, and the presence of this flame thus indicates the formation and recombustion of carbon monoxide in the way described. After the coal has all been thoroughly ignited and raised to a bright glowing heat, the combustion into carbon dioxide is completed at once, and there is little or no formation of carbon monoxide to be burned as a gas above the grate. The thinner the fire the more quickly is this condition reached.

The combustion of semi-anthracite and of anthracite coal proceeds in the same general manner as for bituminous coal, except that the period of distillation becomes shorter and less important as the proportion of hydrocarbon is decreased. It thus results that an ordinary anthracite coal burns almost entirely in the manner described for the coke residue of bituminous coal, except than in consequence of the lower temperature of the fuel during the early stages of combustion, there is apt to be a more pronounced formation of carbon monoxide for the combustion of which there must be a supply of air above the grate as already noted.

[3] Impurities in Coal. Clinker Formation. The chief impurities in coal may be divided as follows: (A) Nearly infusible slate, stone, and earthy matter, either in separate lumps or distributed through the coal as a whole, thus giving it a low carbon value. (B) Mineral materials more or less fusible, and thus capable of melting and forming a slag which uniting with the ash and slate forms clinker. Substances liable to be present in coal and which are more or less fusible at the high temper-

atures in the furnaces are: *Potash, soda, lime* and *silica*. The melting point of these substances is also considerably lowered by mixing with iron oxide, which is always formed by the oxidation or combustion of iron pyrites. The presence of this substance in the coal will thus result in lowering the melting point of the other mineral earths and impurities, and in the greater liability to form clinker. This formation of clinker may be so considerable as to seriously interfere with the combustion of the coal, and in such cases its removal must be carefully attended to from time to time in order to keep the fires in good condition.

Iron oxide, or common iron rust as we call it more familiarly, will give to the ashes a reddish tinge so that such a color noted in the ash may usually be accepted as an indication of the presence of iron pyrites in the coal, with the various results which have been already noted. Its presence in any considerable amount is also usually shown by a yellowish or brassy appearance of the coal. For the formation of little or no clinker a coal should have little or no alkali, lime, or pyrites. Such coal in burning gives a nearly white, soft and friable ash.

[4] Weathering of Coal. When coal is exposed to the air and weather for a considerable period of time there is a slow absorption of oxygen, and thus a real combustion and wasting of the fuel value of the coal. It thus results that the coal during this operation is really burning up, though at a rate so slow that the heat developed is hardly appreciable and the change in the outward appearance of the coal is so gradual as to escape ordinary notice. The hydrocarbons are much more readily subject to this operation of gradual oxidation or combustion than pure carbon, the latter entering only with great difficulty into union with oxygen at ordinary temperatures. It thus follows that bituminous coals are much more subject to waste and change by weathering than anthracite coals. In addition to the loss due to this slow combustion there is often a gradual escape of gaseous hydrocarbons imprisoned within the lumps, or a gradual vaporization of liquid hydrocarbons and their escape as vapor. Such losses also are, of course, more marked with bituminous than with anthracite coals. A bituminous caking coal often becomes changed to a non-caking coal after exposure to the air and weather for a considerable period of time.

The chief external conditions which may influence *weathering* are *moisture* and *heat*. If the coal contains no iron pyrites, moisture is believed to slightly retard the operation of slow combustion, and thus to act beneficially rather than the reverse. If iron pyrites is present in the coal, the conditions are changed. Iron pyrites oxidize with comparative readiness at ordinary temperatures, both the sulphur and iron uniting with the oxygen. It thus tends to set up the operation of oxidation and to break up the lump into small bits, while the heat developed is a further aid to the continuance of the process. The oxidation of iron pyrites is, moreover, much aided by moisture, which therefore, with such coals, becomes a distinct disadvantage. In any event a coal with iron pyrites may be expected to suffer more seriously by weathering than one free of this substance. In extreme cases the oxidation of the pyrites has caused the crumbling of the coal into such small bits that it has become nearly worthless for its original purposes.

Heat in general always increases the activity of this slow combustion, and hence tends to increase the loss due to weathering. The heat developed by slow oxidation in the interior of large piles or masses of coal escapes with great difficulty and thus accumulates and raises the temperature, thus making the conditions still more favorable for the continuance of the process. So far as this effect goes, therefore, the loss would be more serious in large piles than in small. This is, however, offset by the greater difficulty which the oxygen has in penetrating to the interior of the pile as it is larger in size. It results that with other things equal there is no great difference in the loss due to weathering with coal either in large or in small bulk.

ELECTRICITY ON BOARD SHIP—PRINCIPLES AND PRACTICE.—XV.

BY WM. BAXTER, JR.

The switch board diagrams, shown in the last article, differ considerably in the manner in which the generators are connected with the line in the act of starting; and, as these relations are of decided importance, it will be well to point out this difference, and at the same time to show what action is liable to follow as a result of defective connections. In Fig. 67 (December, 1898, issue) it will be noticed that the wire marked *c*, which leads from the top brush, is permanently connected with the bus marked *1*, and which, as already explained, is the equalizing bus. Now if the switch *S* of any one of the generators is opened, the connection of wire *c* will not form a closed circuit, because the wire *b* will be disconnected from bus *2*. When a generator is disconnected from the line, it is generally stopped, but if it remains running, the opening of the *S* switch will not prevent a current from circulating through the shunt coils, hence under such conditions it is desirable to be able to open the circuit. It can be accomplished in two ways, one is by moving the switch of the rheostat *R* to a point which breaks the connection, and the other is by opening a separate switch provided for that purpose. The latter arrangement is the best, as then the position of the rheostat switch is not disturbed. When it is desired to connect the generator with the line again it is necessary to close the circuit through the shunt coils and thus allow the machine to develop an E. M. F. equal to that of the other generators before it is thrown in circuit. If this were not done, the result would be that the current from the bus bars would return through the generator if the voltage of the latter were the lowest, and thus convert it into a motor for the time being. In consequence of this action, the engine would be driven not only by its own steam, but also by the power developed by the generator acting as a motor. It is quite evident that under these conditions the speed of the engine would be considerably increased, as its governor could have no effect upon the velocity caused by the action of the motor. If the generator voltage were higher than that of the bus bars, the reverse effect would be produced, that is, the other generators would be driven as motors. In either case the action would be only momentary and, except under extraordinary conditions, not productive of any damage other than a decided disturbance of the line currents. It is necessary, however, to avoid such disturbance and on that account means have to be provided whereby the generator that is to be connected with the line may be brought to the same voltage before it is connected. If we were to connect the shunt coils of the generator only, and adjust the rheostat until the proper pressure were obtained, and then threw the main switch, the result would not be satisfactory; for as can be seen, as soon as this was done, the current developed by the generator would pass through the series coils and thus increase the voltage. It will be clear, therefore, that a current must pass through the series coils before the generator is connected with the line, so that the voltage may be adjusted with the current conditions the same as they will be after the main switch is thrown into the active position. With the connections as shown in Fig. 67 this is accomplished by having an independent switch in the wire *b* by means of which this wire may be connected with bus *2* before switch *S* is turned. When such an arrangement is adopted, the auxiliary switch is generally located near the generator.

With the type of switch board connections shown in Fig. 68 (December, 1898, issue) the series coils are connected with the bus bars by means of a switch that connects wire *c* with bus *1*, and wire *b* with bus *2*. It is not absolutely necessary to have the wireing connections such that the series, as well as the shunt, coils of a generator can be connected with the line before the generator itself is connected, for it is possible to adjust the voltage to the proper point by making the necessary allowance for the increased effect of the series coils, but in estimating what this allowance should be there is room for serious error, hence the method is not advisable.

In Fig. 69, which represents diagrammatically the switch board of the steamer St. Paul, of the American line, the arrangements for connecting the series coils with the line in advance of the generator are very complete. It will be noticed that there are two switches, marked *S* and S', for each generator. Tracing out the connections of these switches with their respective generators, it will be found that *S* connects with wires *a* and *b* and that S' connects with wires b' and *c*, the former being a branch of wire *b*. Switch S' connects with buses *1* and *2* and switch *S* connects with buses *3*, *4*, *5*, *6*, and *7*. It will be noted that wire *a* of all the *S* switches connects with bus *7*, while wire *b* of each generator connects with a different bus; the object of this arrangement will be made clear presently. The construction of this board is such that four generators can be used continuously while one is held in reserve, the idle machine being the one shown at the extreme left. The wire *b* of this generator connects with the center contact of switch *S1*. If the switches *S* and S' of any one generator are opened, the machine will be disconnected entirely from the line. Now suppose it is desired to start up this generator again, then if switch S' is closed wire *c* will be connected through it with bus *1* and wire *b* with bus *2*, the former connecting through wire c' and the latter through wire b'. By the closing of switch S', therefore, the series coils of the generator are connected in parallel with those of the other machines, and on this account will be traversed by a current of the same strength. Under these conditions the E. M. F. developed by the armature will be nearly the same before switch *S* is closed, as after, for in both cases the current through the series coils will be the same, and so will that through the shunt coils. As a matter of fact the E. M. F. will be slightly lower after switch *S* is closed, owing to the fact that then a larger current will flow through the armature and as a result the extra voltage absorbed by the armature resistance will have to be deducted from the total E. M. F. This reduction, however, will be small and will only result in causing the generator to develop less than its proper

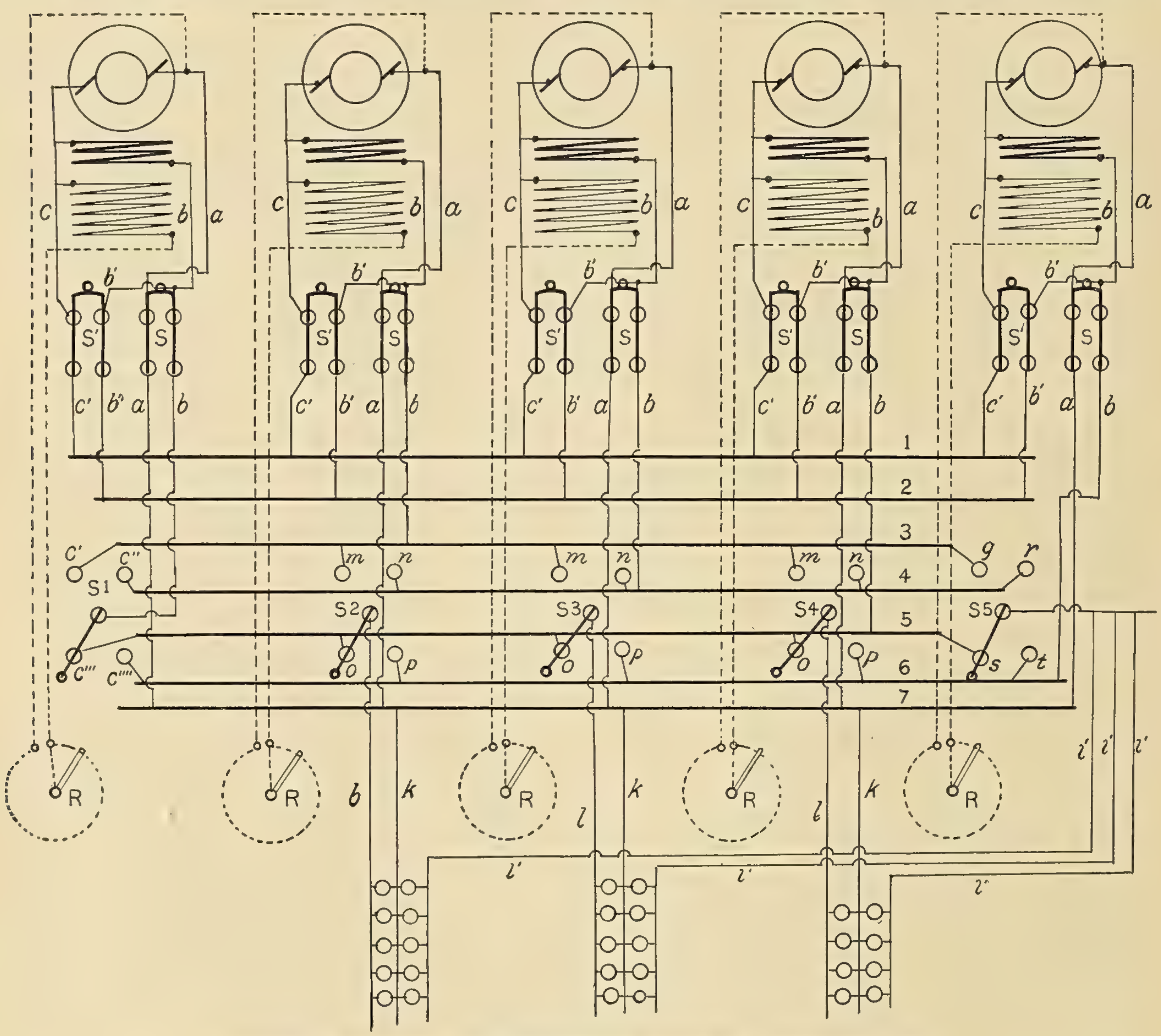


DIAGRAM OF DYNAMOS AND SWITCHBOARD OF S.S. ST. LOUIS.—FIG. 69.

amount of current, and this difficulty can be corrected at once by cutting out a small amount of the rheostat resistance. The arrangement does not render it possible to effect a perfect adjustment of the voltage, before the generator is thrown into service, but prevents its connection when the E. M. F. is so low that the current would be reversed. A little reflection will show that if the series coils are put in circuit before the armature is connected, the current developed by the latter, cannot at the most be reduced to zero, it will surely be something more than that, and will thus only require a slight adjustment of the regulating rheostat *R* to bring it up to the proper strength.

The reserve generator by being connected with switch *S1*, can be made to take the place of any one of the active machines, for, as will be noticed, the contacts of this switch connect with the buses *3*, *4*, *5* and *6*, to which the wires of these generators connect. Suppose for example that generator *No. 2*, counting from the right hand side, is to be replaced by the reserve machine, then after it is cut out, and the reserve machine has been brought up to the proper voltage, by connecting it with buses *1* and *2* through its *S′* switch, the handle of switch *S1* is turned so as to rest upon contact *c′″*. If now switch *S* of the reserve generator is closed, the *b* wire will be connected through the center contact and contact *c′″* of switch *S1* with bus *5* which is the one with which the *b* wire of generator *No. 2* is connected.

As the lever switch *S1*, can be moved so as to cover any one of the four outside contacts, and as these connect individually with the buses *3*, *4*, *5* and *6*, it is clear that the idle generator can be made to take the place of any one of the active machines, in just the same manner as explained above in connection with generator *No. 2*.

The external distribution circuits through which the current is conveyed to the lamps and motors are so arranged that they can be transferred from one generator to any other. In the diagram only three of these circuits are shown, for the sake of simplicity, but in reality there are about twenty. One of the wires of each of the external circuits, that marked *l′*, connects with the centre contact of switch *S5*, the wires marked *l* connect each one with an independent switch as shown at *S2*, *S3*, *S4*. These switches are constructed upon the same principles as *S1*, so that by moving the handle so as to cover any one of the four surrounding contacts, the wire *l* can be connected with the particular bus with which this contact connects. In the diagram, all the switches, *S2*, *S3*, *S4* are set so as to connect the *l* wires with bus *5*.

The wires *l* and *l′* connect through the lamps or motors with wire *k* and thus with bus *7*, which, as already explained, connects with the wires of the generators. By means of this arrangement it becomes possible to shut off, from the switch board, a portion of the lights in all the circuits or in any one circuit, as may be desired. To cut out a portion of the lights in all the circuits, the switch *S5* is opened, thus breaking connection between the *l′* wires and bus *5*. The individual circuits can be turned off by opening the other switches, thus opening switch *S3* would cut out the lights between wires *l* and *k* in the center circuit. The *l′* wires can be connected with any bus by simply turning switch *S5*.

From the foregoing explanation of this switch board it will be seen that it is very complete and that it facilitates the shifting of the load from one machine to any other or from one circuit to another to the greatest extent. The idle machine can be substituted for any of the active machines, any machine can be connected with any or all of the external circuits, and in fact every combination necessary can be effected. In the diagram the circuit breakers and the volt and ammeters are not shown, but from the explanations of their location in the circuit, given in connection with other diagrams, the manner in which they should be disposed can be readily understood.

ENGINEERS' DICTIONARY—XIII.

Dead-Water.—The water in the bottom of a Scotch boiler being removed from the direct application of heat tends to remain constantly at a lower temperature than the water about the tubes and furnaces. The former does not, therefore, readily join in the circulation within the boiler, but tends to remain fixed in location at the bottom of the shell. It is on this acount sometimes known as *dead-water*. The same term is also applied to the water following a vessel with full stern. As well known, it consists of eddies and whirls, rather than of smooth stream line flow, as in the case of a vessel with finer run and better form.

Disc Area *of Propeller*.—The area of the circle swept by the tips of the blades. The actual surface of the blades is usually related to the disc area, the ratio ranging from .20 to .50 with propellers of different forms and for different kinds of service.

Disc Crank.—A crank in which the *throw* or *web* consists of a circular plate or wheel with the shaft in the center, and the crank near the circumference.

Disc Valve.—In some cases the valve is of rubber or other flexible material, and is controlled by a guard secured in place over it as in Fig. 46. In other cases the valve is of metal or other non-flexible material,

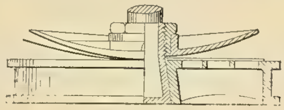


FIG. 46.

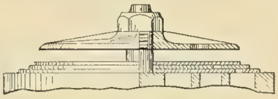


FIG. 47.

and is controlled in its lift by a stop or guard carried on the central stud on which the valve rises and falls. See Fig. 47. A low spiral spring is also usually added to insure quickness of closure. The valves shown are a patented type.

Discharge *Cock—Valve—Pipe—etc.* See *Delivery.*

Dog.—A bar or girder for securing a man-hole plate in place on a boiler. The stud or bolt of the plate passes through the dog and is secured by a nut which draws the plate hard and fast against its seat. See

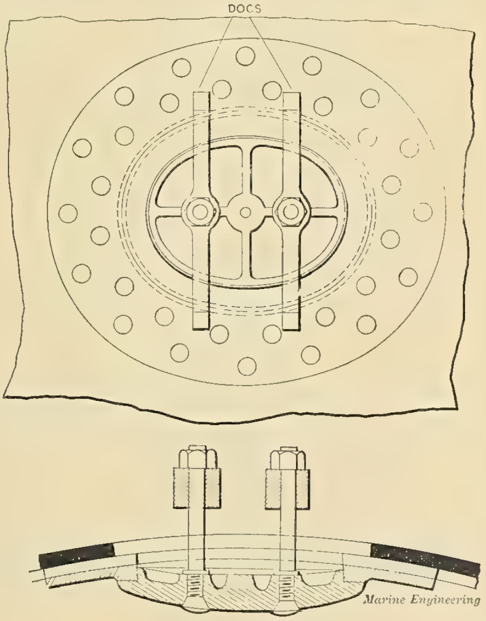


FIG. 48.

Fig. 48, showing the upper part of a Scotch boiler shell with the man-hole plate secured in this manner by two dogs.

Dome or *Steam-Dome.*—An extension or additional space on top of a boiler to give more steam room and to provide a place from which comparatively dry steam may be taken. A steam dome is commonly provided on locomotive boilers and in other cases where the steam room is limited in amount or restricted in height. In the "*Leg*" boiler (see under **Boiler**, Fig. 7) the steam dome takes the form of the so called *steam chimney.* As shown in the figure this is a space surrounding the base of the funnel. As the waste gases pass upward inside the funnel they give over a part of their heat to the steam which is thus dried to a greater or less degree, or even in some cases slightly superheated. In the ordinary Scotch boiler (see under **Boiler**, Fig. 6), a steam dome is rarely needed and but seldom met with.

Donkey Engine, *Boiler, Pump, etc.*—Terms signifying an engine, a boiler, a pump, etc., used for miscellaneous and auxiliary purposes. Thus the donkey boiler is a small boiler used when in port or at other times for operating auxiliary machinery such as deck winches, steering-gear, anchor-hoist, electric lighting machinery, pumps, or for heating ship, etc.

Double Acting Engine, *Pump, etc.*—In the usual type of steam engine, steam is admitted to, and acts alternately upon, both sides of the piston. Similarly in the usual type of independent pump, water is admitted to and discharged from each side of the piston alternately. Such an engine or pump is said to be *double acting.* In the *single acting* engine or pump the action is on one side or stroke of the piston only, as in most forms of gas engines, or in the ordinary air-pump (see under that head), or in the plunger form of feed pump.

Doubling Plate or *Reinforce Plate.*—A plate used to stiffen or strengthen the metal of a boiler shell, or other like structure, in the vicinity of a man-hole

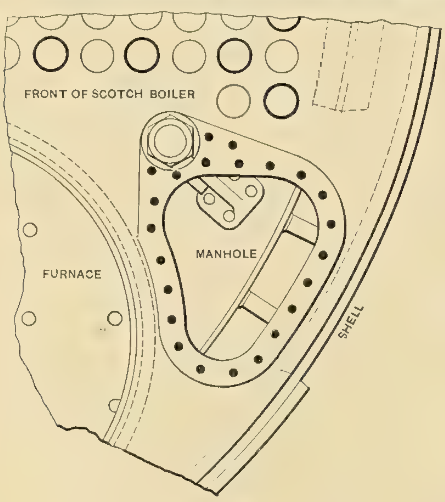


FIG. 49.

or where for other reasons, greater stiffness is desired. It consists simply of a plate riveted to the shell as in Fig. 49, showing the reinforce plate around a boiler man-hole.

Down Comer, *Down Cast Pipe,* or *Down Flow Pipe.*—A pipe in a water-tube boiler for returning the water from the upper drum to the lower drum or feeder for the tubes. It is much larger in size than the steam forming tubes, and is situated usually outside the boiler shell, or in any event is shielded from the direct action of the hot gases. See also under **Boiler**—*water tube.*

Draft.—A term referring to the difference between the pressures of the air in the ash-pit and the gas in the base of the funnel, and hence to the pressure which tends to force the air through the fire and maintain the combustion. Good draft implies a considerable difference of pressure, large quantities of air forced through the fire, and good combustion. Poor draft on the other hand implies but little difference of pressure, small quantities of air forced through the fire, and poor combustion.

Draft Gauge.—See *Air Gauge.*

Drain Cock—*Valve Pipe.*—A cock, valve or pipe for the purpose of allowing and regulating the removal of water from a cylinder, a steam pipe, or other closed space.

Drain Gear.—A term referring in general to a drain cock, valve or pipe, or to any of the rods, levers, handles, etc., which may be provided for operating them.

Drift-Pin.—A tapering steel pin formerly used in boiler making in order to enlarge and bring together rivet holes which do not come quite fair in overlapping sheets. The use of the drift pin results in the stretching and deformation of the metal around each hole, and its elongation into a more or less oval form. These are often very imperfectly filled by the rivet. In modern practice with drilled holes carefully laid out there should be no need for the drift-pin, and in most specifications its use is strictly forbidden.

Drip-Cock—*Valve Pipe.*—See *Drain Cock, etc.*

Drum.—A general name given to a hollow cylindrical chamber, as for example the steam and water *drums* of a water-tube boiler, see **Boiler**, Figs. 8 to 11. In certain forms of boilers, also, the steam dome takes the form of a relatively small horizontal cylinder or drum lying over the main boilers and connected to them by two or more short lengths of pipe known as *goose necks.*

Dry-Pipe.—A pipe in the upper part of a boiler for collecting the steam and for effecting at least a partial separation of the water from the vapor. As fitted in modern practice the dry-pipe consists of a pipe running the length of the boiler, closed at the end, and provided on top with a large number of small slits or holes. In the aggregate the cross-sectional area of these openings is about the same as that of the pipe. The upper surface of the pipe thus fitted acts somewhat as a strainer, and prevents the inflow of water in bulk in case a large mass should in any manner find its way into the steam space in the top of the boiler.

Dry Steam.—Steam which does not contain liquid water in suspension. Dry steam is transparent and colorless as the air. Witness for example the space above the water in a gauge glass. Steam escaping into the air is rendered visible by a more or less complete condensation into fine particles of water. Such steam, or vapor mixed with water in this condition, is said to be *moist* or *wet.* Steam as provided by the ordinary boiler has usually in suspension an amount of water varying from, perhaps, three or four per cent. down to nothing. The quality of steam refers to the proportion which is vapor. Thus a quality of 98 per cent means 98 per cent vapor and 2 per cent water. Dry steam would have a quality of 100 per cent.

Dynamometer.—The word means literally *force measure.* It is also used in the sense of *work* or *power measure.* As a force measurer the dynamometer may be represented by the common spring balance for weighing. When such a spring balance or some equivalent device is used for measuring the pull or push or twist between two parts of a machine or between a moving body and some other body pulled or pushed or turned by it, the arrangement is usually called a *transmission dynamometer.* The force transmitted being thus measured and the speed of transmission being known or measured, the work and power transmitted can be directly found by multiplying the one by the other. In the *absorption* dynamometer the *torque* or twisting moment of the engine shaft is measured, and this together with the revolutions furnishes the necesstry data for computing the work. The latter instead of being transmitted on, as in the *transmission* dynamometer, is absorbed by the apparatus and transformed into heat. The most common form of absorption dynamometer is the Prony brake in some one of its many forms. A typical arrangement is illustrated in

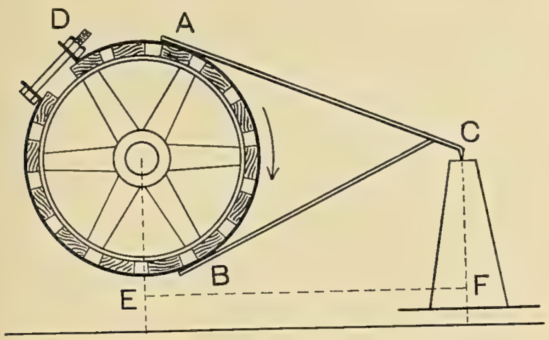


Fig. 50.

Fig. 50. The brake is this case consists of a number of blocks of wood carried by a sheet metal band and provided with arms A C and B C. This is placed on a brake wheel driven by the engine whose power is to be measured. The nut *D* provides for adjusting the tension of the brake on the wheel. The strut *C F* rests on a platform scale or other means of measuring the force required to keep the brake from turning around with the wheel. By means of the nut the tension is adjusted as nearly as possible so as to keep the beam of the scale floating, thus indicating a constant force at such value as is shown by the beam poise. Let *P* denote the value of this force, *a* the arm *E F* and *N* the revolutions. Then the work absorbed is given by the formula:

Work = 6.2832 $P\ a\ N$.

Ebullition.—The act of boiling. When water boils or is in *ebullition*, vapor is formed in globules at the heating surface. These rise to the surface of the water and there escape, thus causing the violent agitation of the liquid which is characteristic of this condition.

It Is Reported

That the great floating dry dock at Havana will not be turned over to the United States, but will be put up at auction by the Spanish Government. It was built in England and cost about $650,000.

That the first torpedo boat destroyer of the Navy to be sent on her trial, the Farragut, reached a speed of 30.1 knots on her final trial at San Francisco. She was built by the Union Iron Works.

That the Manhattan Dry Dock & Construction Co., incorporated under the laws of West Virginia with a capital of $5,000,000, will establish a shipyard in New York harbor. The articles of incorporation give the company the right to "build, repair, sell and operate ships, vessels, etc."

That representatives of Vickers, Sons & Maxim, of England, have looked over the Newport News shipyard, and reported in favor of the purchase of a large interest in it by the English concern, with the intention of adding to it a modern gun factory. As is well known this English concern is one of the most prominent manufacturers of modern weapons in the world.

CORRESPONDENCE.

[*Communications on matters of interest to marine engineers, for insertion in the correspondence department, are solicited. These, wherever possible, should be supplemented by rough sketches or drawings, which will be reproduced if necessary to illustrate the subject, without cost to the writer.*

Full names and addresses should be given, but publication o these will be withheld where requested.

We do not assume responsibility for the opinions expressed b correspondents.]

Efficiency of Naval Engineers.

Editor of Marine Engineering:

In the report which appears in the columns of your December issue of the recent meeting of the Society of Naval Architects and Marine Engineers, I note the following statement:

"We have only very few officers of the Engineer Corps competent to give experienced trained engineering supervision to those repairs on torpedo boats which are attempted at navy yards, and those few are rarely available for duty."

This is a grave charge against the efficiency of an important branch of our navy, for, if naval engineering officers are not competent to supervise such repairs to torpedo boats as are considered to be possible to attempt at navy yards, it is surely high time, in view of the frequent mishaps to which torpedo boat machinery appears to be subject, for the navy to set about securing officers who do possess the necessary professional qualifications. Moreover, the bearing of the charge is not limited to the specification cited, for those not sufficiently competent to supervise repairs to torpedo boat machinery are hardly a class of men to whom to trust supervision over the repair of the complicated and often delicate machinery met with in modern warships in general.

As the charge quoted is made in a paper presented before a national professional body, and is under the name of a naval officer of high rank, who, moreover, I note is referred to in the discussion as the commander of the torpedo flotilla during the late war, it would appear that the Navy Department should take cognizance of it.

Personally, I do not believe that the statement in question is warranted, for it belies the efficiency which the corps of naval engineers displayed during the late war when serving in the fleet or in repair ships, which efficiency is a matter of official record and, it may be added, of congratulation to the American engineering profession in general. Nevertheless, in view of the publicity given to the charge and the implication of general incompetency that it carries with it, and in view also of the rank and the late service of the officer responsible for the statement, the Washington naval authorities would seem to be called upon to investigate it in the interest of the country in order that the necessary measures may be taken if it be proved well founded; and in fairness to the personnel of the naval engineering corps that they may, in the contrary case, be relieved of the suspicion to which the charge gives rise concerning their professional competency in general.

Member Soc. N. A. & M. E.

The dispute between the Government and the contractors for the new monitors, referred to in our December issue, has been settled by the decision to let the single turret design stand, only increasing the vessels in length by 27 ft. and the displacement by about 500 tons. The original contract price will be increased by about $100,000 in each case. The amended design will give vessels of 3,235 tons displacement. They will have a maximum speed of 11 1-2 knots and total capacity for 400 tons of coal.

QUERIES AND ANSWERS.

Communications intended for this department will not receive attention unless accompanied by the full name and address of the sender, which will be considered confidential.)

Q.—Have compounds used in boilers to prevent scale any effect on the steel or iron? J. A. C.

A.—This depends altogether on what is used. There are many compounds which are quite safe and others which tend more or less actively to corrode the plates, tubes and braces of the boiler. Some compounds contain tannic acid which attacks iron and steel strongly, and others contain a variety of substances more or less liable to corrode or attack the boiler, especially if used too freely.

A very good plan is to take a pail full of water containing the compound in proportion somewhat stronger than as used in the boiler in order to increase the effect. Then boil this and put into it a piece of boiler plate or like material and watch for a few days, or even for two or three weeks, weighing the plate from time to time to note the loss, if any. Still more rapidly the probable effect may be arrived at by using a piece of well polished steel and watching carefully from day to day any signs of discoloration or corrosion on the surface. If the surface becomes rusted or blackened in marked degree, or pitted, it will be safe to avoid the use of the compound which produced this effect.

Q.—We have been discussing why a steel ship floats and can't agree. I've seen a water-logged lumber schooner which had been floating for days, and I reckon a steel ship with as much water in her would go down quickly. * * * * * * Why doesn't a big battleship with so much weight go to the bottom instead of floating? KEY WEST.

A.—To answer your question let us first understand clearly that a ship floats for the same reason that a cork or a pine stick does. This does not tell us much, to be sure, but it is an advantage to be able to see clearly at the start that the flotation of all bodies has one common cause and one common explanation. This explanation cannot be given completely, however, without introducing a mathematical discussion based on the properties of liquids, and such a mode of treatment would not be in place in this discussion of the subject. As the next best thing, then, we must admit the following principle, which may be shown experimentally to be true in all cases:

A body wholly or partly immersed in a liquid is pressed or buoyed upward by a force equal in amount to the weight of the liquid displaced.

By the liquid displaced is meant a volume of liquid equal to the volume of the body, if wholly immersed, or to that part of the body below the water surface if partly immersed.

Suppose, then, that we start in with a solid block of steel 12 in. by 12 in. on the base and 18 in. high, supported by a rope from a convenient point, and allowed to sink in sea water to an immersion of 12 in. The displacement would be just one cubic foot, and the weight of this volume of sea water 64 pounds. The weight of the steel would be about 720 pounds. Hence, we have a pull downward of 720 and a push upward of 64, and hence a net pull on the rope of 656 pounds. Suppose now that without disturbing the block we imagine it scooped out on top. We need not be concerned as to the means of doing this, but simply suppose the material removed and the block thus made more or less hollow with sides and bottom left untouched. Suppose in this way 100 pounds were removed. The weight would then be 620 pounds. The displaced water, however, would remain unchanged in amount, and the upward force of 64 pounds act as before. Hence, the net pull on the rope would now be reduced to 556 pounds. Continuing in this way we may suppose finally 656 pounds of steel removed, leaving a hollow steel box with relatively thin sides, and weighing 64 pounds. The depth of immersion and the amount of displaced water would remain the same, and the upward or buoyant force would still be 64 pounds, and therefore just sufficient to balance the weight and reduce the pull on the rope to nothing. The rope having nothing to support could now be removed and the box would float freely in this condition. Why? Because the weight downward was just balanced by the buoyancy or pressure upward.

Suppose we kept on and removed more steel amounting to, say, 14 pounds. The box would then weigh 50 pounds, while at the immersion of 12 in. it would still experience an upward push of 64 pounds. There would hence be in this condition a net upward push of 14 pounds, in answer to which the box would rise, thus decreasing the amount of displaced water. This would continue until the upward push became reduced to 50 pounds, the equal of the downward weight. This would occur at an immersion of 9 3-8 in. (in this particular case), in which condition the box would float freely. On the other hand, suppose some of the chips were thrown back, bringing the total weight up to 80 pounds. In answer to the excess of force downward the box would settle in the water until the weight was again balanced by the increased buoyancy. For 80 pounds this would occur at 15 in. immersion. Thus the box would rise and fall according to the weight carried, but in each case when floating freely the buoyancy upward would just equal the weight downward.

Now, suppose a hole drilled in the bottom of the box. Water will flow in. Such an inflow may be looked on either as a loss in buoyancy or as an increase in cargo. For our present purposes the latter is the simpler. Suppose, then, that the water flows in until it is 3 in. deep over the bottom of the box and the hole is then plugged. What happens? The weight of water introduced is about 14.7 pounds, and the total weight, box and water cargo, is 78.7 pounds. It, therefore, settles as before until the immersion is such that the total displacement gives an equal buoyancy of 78.7 pounds, which will occur at a draft of about 15 in. If, instead of plugging the hole the water is allowed to run in, the box will continue to sink deeper and deeper in the endeavor to gain more buoyancy. By the time the water is about 6 1-2 in. deep inside, the top of the box will be brought to the level of the water outside, no additional buoyancy can be gained, and if the top is open the box will suddenly fill and sink. Why? For the same reason that any lump of steel would sink, because the weight is greater than the buoyancy, or the weight of the steel is greater than that of an equal bulk of water. If a thin water-tight deck or cover had been fitted over the top, the filling would still proceed through the hole, and the box sink none the less, and for the same reason as before.

In further illustration of the same principles, suppose we have a solid lump of wrought iron. We throw it into water, and it sinks. We beat it out into a thin sheet, and it sinks just the same. We next cup the sheet and so form a shallow dish or bowl. It now floats. Why? There is the same amount of material as before. Simply because in the last case we had so formed the body that the water it could displace was far greater than its own volume—many times greater, in fact. As a lump or as a plane sheet, it could only displace water corresponding to its own volume. In the form of a bowl it could displace in addition the inside volume, and this great increase of displacement meant an additional buoyancy which enabled it to float and even to carry a load. Pierce the bottom of the bowl, water flows in, and the bowl sinks because now it can only displace, even when down to the water's edge, a volume of water equal to the volume of the material—the same as when in the condition of a flat plate. In the same way the plates, angles, beams, etc., going to form a steel ship would all sink if thrown individually into the water, but if they are so disposed as to form a ship, which is after all a kind of cup or bowl, the water which can be displaced is enormously increased, and the ship floats and carries her cargo as well. Knock a hole in the bottom, water flows in, buoyancy is lost. and if the compartment is large or is not water tight, the ship fills and sinks in the same way and for the same reason as in the case of the bowl.

Q.—Can you give me information in regard to the Civil Service examinations for admission to the Government service as Naval Architect? C. H. G.

A.—The naval constructors in the Government service are graduates of Annapolis, but qualified persons from civil life are employed by the Bureau of Construction and Repair of the Navy Department as draftsmen, assistant draftsmen and tracers, after having passed the Civil Service xaminations Applicants are required to file with the Civil Service Commission at Washington, on a special form, certificates from their present employers or instructions "testifying to their skill and adaptability." For draftsmen, the examination extends over four days, and includes these subjects: Letter Writing; Applied Mechanics; Ship Calculations; Practical Shipbuilding; Ship Drafting. For assistant draftsmen three days are allowed, and the same subjects are required as for draftsmen with the addition of Arithmetic. Less percentages are necessary, however, in some of the subjects, and generally the questions are not so difficult. For the position of tracer, a two-day examination is given and the requirements are: Penmanship; Letter-Writing; Arithmetic; Tracing Ship Drawing; Free Hand Lettering. In some of the subjects the questions following the practice of the Navy rather than the mercantile marine. The salaries of the positions are, approximately: Draftsmen, $1,550 to $2,000 per annum; Assistant Draftsmen, $1,250 to $1,550 per annum, and Tracers, $1,000 to $1,250 per annum. You can get more detailed information about these examinations by addressing the United States Civil Service Commission, Washington, D. C.

Recent Legal Opinions in U. S. Courts.

We have before us a number of recent opinions delivered by judges of the Federal courts, and from them have made a selection of several which contain points of special interest for those engaged in marine work. We have disregarded the merely legal technicalities in each, confining the reports to the points here referred to.

NAME PLATE FOR BOILER.

Suit was brought by H. M. Sciple and others in the District Court of New Jersey to recover the balance due on the purchase price of a boiler built for the steamer Otha J. Sample. The contract called for one vertical marine boiler of certain dimensions subject to the tests and regulations prescribed by Federal law. The boiler was to pass the U. S. inspection for 125 lbs. of steam, working pressure, and to be complete, with grates, waterpan and hood. There was a dispute regarding an allowance to be made for this hood, which was not supplied, and a claim also by the purchaser of the boiler, one Sample, for an allowance because the makers failed to furnish with the boiler a "name plate" showing the name of the maker, the place where manufactured, and the tensile strength. After listening to the evidence, Judge Kirkpatrick found that in every respect that which was furnished complied with the requirements of the contract, the hood specified being omitted only by agreement. Then quoting the 4431st section of the revised statues which requires "that every plate of boiler iron or steel made for use in the construction of steamboat boilers shall be so stamped in such places that the marks shall be left visible when such plates are worked into boilers," the Court held there was not any statutory requirement for a "name plate" such as the defendant had demanded, nor was it called for in the contract. Consequently he gave the parties who furnished the boiler judgment for the amount claimed.

LIENS FOR ENGINEERS' WAGES.

A very interesting decision defining the rights of employees of a dredging company to establish liens for wages due was made by District Judge Hanford in the State of Washington. The Bowers Dredging Co., an insolvent corporation, was in the hands of a receiver and under the jurisdiction of the U. S. Court. Certain engineers, firemen and deck hands sought to intervene, claiming to have maritime liens upon the dredges of the company for wages due and unpaid. The company had operated two hydraulic dredges in the harbor of Seattle under a subcontract from a harbor improvement company which had a contract with the State. Discussing the rights of the employees who intervened the Court says:

"The main question in the case is whether the dredgers are vessels subject to admiralty process, whether the work which they were doing was a maritime service, whether the contracts under which they were supplied and kept in repair are maritime, and whether their crews have maritime liens for their wages. The writers and judges who have expounded maritime laws, and the rules by which the jurisdiction of admiralty courts must be measured, have not succeeded in making known any satisfactory test by which floating structures which are subjects of admiralty jurisdiction, and to which maritime liens may attach, may be distinguished from those which have no place in the realm of maritime jurisprudence. There are numerous decisions which tell that adaptability to float on the water, masts, sails, propelling machinery, steering apparatus, capacity for carrying merchandise or passengers, and mobility, are features by which a subject of admiralty jurisdiction may be recognized; but the decisions are not all consistent with any guiding principle which makes admiralty jurisdiction depend upon the size or shape of a vessel, her means of propulsion, or her adaptability for use. According to the decisions, a ship, although afloat, is not a ship if her original construction, rigging, and furnishing remain incompleted. Men employed on board of a vessel for her preservation do not acquire maritime liens for their wages if she is out of commission; that is, if she has no voyage in contemplation. A ship is not employed in a maritime service when used merely as a warehouse to hold her cargo after the completion of a voyage, and while navigation is suspended. The actual employment of a structure designed for use in the transportation of merchandise or passengers by sea is not under all circumstances conclusive. Wharves and warehouses are necessary for the transportation and preservation of merchandise to be carried in ships to a distance, and yet such structures, although in fact instruments of commerce and aids to navigation, are not maritime vessels. Floating dry docks, used in the repair of vessels, are not maritime things. On the other hand, a private yacht or pleasure boat, not designed for nor employed in trade or commerce, is a vessel which may be a subject of admiralty jurisdiction. The width of a stream or the length of a voyage is no criterion by which to determine the character of the service, nor the question of admiralty jurisdiction. Neither will jurisdiction of a floating structure be denied by a court of admiralty because it does not carry masts, propelling machinery, or steering apparatus, or lacks accommodations for a crew. There is great confusion in the decisions as to whether particular structures, such as pile drivers, wharf boats, rafts, and dismantled vessels, are to be classed within or without the pale of admiralty jurisdiction."

Then follows a list of cases in which jurisdiction was sustained over a great variety of floating structures, including a floating elevator; a harbor tug of less than five tons; a scow; a canal boat used only upon an artificial canal wholly within one state; a barge without masts, sails, propelling machinery, rudder or anchor; a ferryboat; a steam derrick boat; a floating boathouse; a floating bath house; a pile driver; a dredge, and a raft of timber. After citing these cases the Court continues:

"A dredging vessel designed to facilitate navigation, by going from place to place, to be used in deepening harbors and channels, and removing obstructions from navigable rivers, and to bear afloat heavy machinery and appliances for use in that class of work, may commit, or be injured by, a marine tort, and she may become subject to a maritime lien for salvage. She has mobility, and her element is the water. She can be used afloat, and not otherwise. She has carrying capacity, and her employment has direct reference to commerce and navigation. I perceive no reason for exempting such a vessel from the liabilities arising from non-payment of the wages of her crew, or from such unfulfilled contracts as would subject other vessels to liens enforceable by a court of admiralty. I find no difficulty in pronouncing in favor of the engineers, firemen, deck hands and captains who worked on board of the dredgers. They have maritime liens for the balances due to them for wages. The captains were not clothed with the authority of masters, but were simply foremen in charge of the working crews. Therefore, the rule that the master of a vessel has no lien for wages does not apply to them. Those who worked as general mechanics in keping the machinery in repair, and the pipe men, who attended to laying, connecting, and moving the lines of pipe, and those who performed necessary labor upon and about the filled area, are also entitled to liens. Their services were required in prosecution of the enterprise in which the vessels were employed. The right to claim a lien for wages under the general maritime law is not restricted to favor only mariners who serve the ship with peculiar nautical skill, but extends to all whose services are in furtherance of the main object of the enterprise in which the ship is engaged."

A decree was accordingly entered directing the sale of the dredges and allowing as preferred claims the amount due the employes for wages.

CONTRACT TICKET CLAUSES.

A point made in a personal injury suit by District Judge Brown in New York is worth noting. Jacob Moses, a four-year-old boy, was a steerage passenger on the Hamburg Line steamship Persia, and in a collision between that ship and another he suffered such injuries to his right hand that it had to be amputated. A clause in his contract ticket limited responsibility of the ship and owners to $100 in case of loss or injury to the passenger arising from steam, latent defects of the steamer, negligence of the company's employees or from negligence in navigation of any other vessel. Referring to this the Court said that had the contract provision been a reasonable one it would have been sustained, but considering the nature of the injuries liable to happen to any passenger through careless navigation (as in this case) including possibly loss of life or limb, and the large awards often made therefore, it seemed to him that the stipulation that the damages for any possible injury should not exceed $100 could not be seriously considered as any reasonable or substantial provision. The sum of $100 was scarcely more than a nominal sum. Considering the occupation of the boy's father and the probable business chances for the boy when grown up, the Court made an allowance of $2,500 to the son and $500 to the father with costs.

A 100 ton floating derrick is to be constructed for use at the New York Navy Yard for the purpose of handling armor plates, ordnance and other heavy material. It will be operated by steam.

In his report Assistant Secretary of the Navy Charles H. Allen calls attention to the unsuitability of wood as a material for dry docks. He says that the wooden dock No. 2 at the Brooklyn Navy Yard is rotting away like the one at Norfolk.

An order for two transatlantic liners, each 560 ft. in length, has been placed at the Clydebank Works in Scotland by the International Navigation Co. The steamships Paris and New York of the Southampton service of this company were built at Clydebank. The new vessels will be put on the Antwerp-New York route flying the Red Star flag.

Arrangements are being made by the Navy Department for the establishment of a naval station at Honolulu, equipped with wharves, cranes, store houses, etc. Land for this purpose has been set aside by authority of the President. Contracts have also been let for the construction of proper coaling facilities on United States property at Pago Pago, Samoa.

RECENT PUBLICATIONS.

THE THETA-PHI DIAGRAM *Practically applied to Steam, Gas Oil, and Air Engines.* By Henry A. Golding, A. M. I. M. E. The Technical Publishing Co., Manchester, England. First Edition, 1898. Size 5 by 7 1-2. Pages, 123. With numerous diagrams. Cloth, 3s.

According to the author's preface the purpose in this book has been to present in as simple and practical a manner as possible the use of the temperature-entropy diagram, and the various methods of drawing it for different heat motors. In the preparation of the book the author has made use of the work of Gray, Boulvin, Williams, Sankey and others in the field, and due acknowledgments are made of indebtedness to these sources. The book is divided into six chapters treating of Entropy, Entropy of Water and Steam, Conversion of Indicator Diagram to Entropy Diagram, Heat Losses, Application to the Gas Engine, Application to Oil and Air Engines. In the first two chapters the fundamental explanations relating to entropy and temperature-entropy diagrams are given, usually in plain and simple form, though of necessity some acquaintance with higher mathematics is assumed. In Chapter III on the conversion of the indicator diagram into the temperature-entropy curve, the treatment is less satisfactory. Some inaccuracies in the details of the mode of procedure seem to have crept in, due perhaps to haste in preparation, but of still more importance, from the standpoint of the principles involved, is the question as to whether the basis of the method is well founded. The author, in common with others whom he has followed in this matter, considers the temperature-entropy diagram as the temperature-entropy history of a certain space or volume instead of the temperature-entropy history of a certain quantity of steam or steam and water. The indicator card is a pressure-volume history of the volume inside the cylinder and its area gives the external work done. If, however, the temperature-entropy diagram is to have definite significance as a diagram showing heat exchanges, it must relate throughout to a constant quantity of the substance. The heat involved in any thermal change in a substance of constant weight Q is $H = Q \int \tau \, d\phi$. If, however, Q is a variable we must put $H = \int Q \tau \, d\Phi$. In the latter case the heat H cannot be represented by an area on the temperature-entropy chart, prepared as it is for 1 lb. of the substance. If the cycle as a whole consists of a series of stops during each of which the quantity involved is constant, then each may be dealt with separately, but their combination into a continuous diagram on the temperature-entropy chart is without definite meaning. The same general objection lies against the application of the method to the various cards individually of a multiple expansion engine. The quantity involved changes many times throughout the various cycles, and the entering charge of working steam is broken up and resubdivided on its way through the engine until its identity is entirely lost. A closed diagram in such case means therefore a *series* of temperature-entropy histories in which the quantity differs from one to another, and therefore in which the area of the diagram does not correctly represent the heat transformed into external work. It is not denied that diagrams derived in this way correspond in area fairly well with the indicator cards to which they correspond, the one being measured in the heat and the other in mechanical units. The differences in any event are small, but it is the principles involved which are called in question, rather than the amount of error resulting. In the fourth chapter the influence of jackets, of superheaters, and of heat losses and variations from the ideal cycle are considered. In connection with these subjects it would have been well to bring into greater prominence the fact that the temperature-entropy diagram is limited to reversible processes. Remembering this and that the actual cycle is full of irreversible features, it is evident that the use of the temperature-entropy diagram involves a considerable element of uncertainty, and any specially close agreement between its area and that of the indicator card can be only accidental in character. In the last two chapters, gas oil and air engines are considered, using the general principles established in the first part of the book. The treatment is simple and perhaps as satisfactory as can be expected from the nature of the subject. Sufficient notice is not given to the fact that here, too, we are dealing largely with irreversible processes, and furthermore that in the gas and oil engine the working substance is a complex mixture of gases changing in character during the stroke and with varying thermal properties. The use of a mean specific heat, and of values of entropy based on it, can be at best but an approximation, but still perhaps the best that can be made under the circumstances. For a more detailed mode of treatment reference may be made to a recent paper by *Stodola* published in the "Zeitschrift des Vereins Deutscher Ingenieure" September 17, 1898. The book closes with a table of the weight of dry saturated steam carried out to tenths of a pound, with difference for hundredths. This will be a great convenience to all who are interested in computations relating to the general subject of steam-engine performance and economy.

"An American Cruiser in the East," by Chief Engineer John D. Ford, U. S. N., is now in its second edition, though but recently issued from the press of A. S. Barnes & Co., 156 Fifth Ave., New York. In view of the acquisition of the Philippines this book is doubly interesting, though aside from its peculiar value in this respect it is a most interesting work, taking the reader through Japan, China and the Philippines as though he had set out on the journey himself. In the scond edition there is an appendix containing a vivid description of the sea fight at Manila, and the events which led up to it. Mr. Ford served on the U. S. S. Baltimore in this eventful action. His descriptions of Japanese and Chinese manners and customs are very complete, and there is a profusion of fine engravings to entertain the eye as the text enlightens the mind. The author is an earnest champion of the policy of expansion. Referring to the natives he says: "They have always wanted liberty and have fought the Spaniards for it on many a hotly contested field since 1522." As to the future he writes: "These people need steamships of from 100 to 500 tons to trade amongst the islands; they need steamships of from 3,000 to 5,000 tons to trade with the United States and other parts of the world; they need railways, locomotives and cars for internal traffic; and they need thin dress goods; all sorts of thin white goods, insertions and laces, black and white prints of thin cotton, silk and woolen goods, thin-woven and knit goods, fancy and staple hardware, tinware, groceries, canned goods and flour, steam engines, pumps, sugar mills, agricultural implements, furniture, books and stationery, and our public school system. They can pay for these with sugar, tobacco, hemp, camphor, rice (which are produced in great quantities, coal, gold and many varieties of beautiful hard woods. Why should our people not have this trade?" The book is finely printed on a good paper, and artistically bound in cloth it costs $2.50.

The Spanish war and its consequences has given great prominence to questions of national defence and foreign policy which have hitherto not received general attention. That the course of events has been foreshadowed by those who have devoted study to such matters is evidenced by the collection of essays written by Captain A. T. Mahan, U. S. N., now published under the title of "The Interest of America in Sea Power," by Little, Brown & Co., of Boston. This work is a collection in book form of several detached papers written for leading literary publications by the distinguished author. They are severally entitled: "The United States Looking Outward," "Hawaii and Our Future Sea Power," "The Isthmus and Sea Power," "Possibilities of an Anglo-American Reunion," "The Future in Relation to American Naval Power," "Preparedness for Naval War," "A Twentieth-Century Outlook," and "Strategic Features of the Caribbean Sea and the Gulf of Mexico." Through the courtesy of the original publishers of these papers they are now available for information and study in a compact form. For the many who appreciate the grave importance of the subjects treated, but who have been too busily engaged otherwise to undertake independent research and reflection, this work will be of great practical value and interest. Space does not permit of any extended notice of the several papers. It will, however, be apparent, considering the subjects and the known scholarly treatment of such by the author, that the work is one that will well repay earnest perusal. The book is of convenient size and is published at $2.00 bound in cloth.

The 1899 issue of the valuable Record of American and Foreign Shipping, New York, has been received. This very excellent index of classifications has been thoroughly revised and brought down to date, and also contains a large number of classifications not included in the 1898 bound issue, the additional pages numbering 129 in the alphabetical list of vessels. It is an invaluable book of reference for those who find it necessary to inquire into the characteristics of merchant vessels and their condition. The work of the Society has evidently been very carefully done, and no vessels are classed except such as have been submitted to survey according to the prescribed rules and the class approved by the Committee at New York. This classification society has made a change of name from the American Ship Masters' Association to the American Bureau of Shipping, which latter is more appropriate and explanatory of the purposes of the organization. The Record is published with the approval of the Boards of Marine Underwriters at New York, Boston and San Francisco. In the present issue the contents include the rules for the construction and classification of all styles of vessels, the Record proper giving the chief characteristics of ownership, etc., of vessels of all types both home and foreign; a convenient index to the compound names of vessels in the Record arranged alphabetically by the last name; also a list of vessel's names which have been changed, and valuable lists of owners, shipbuilders, etc. Though a minor detail the manner in which the Record is gotten up deserves mention for its excellence. In the arrangement of the matter, in printing, press work and binding, it is a remarkably fine specimen. The address of the Bureau is 37 William street, New York city.

Students of French who desire to profit by study of the many valuable works in that language on subjects related to marine engineering and architecture often meet with difficulty in comprehending technical words and phrases which the ordinary dictionary does not contain. For such the "Technical Dictionary of Sea Terms, Phrases and Words" in both languages, published by Crosby, Lockwood & Son, 7 Stationers' Hall Court, Ludgate Hill, London, is a most useful pocket book of reference. It is intended, indeed, for the use of "seamen, engineers, pilots, shipbuilders, ship owners and others," and is the work of a thoroughly practical seaman, William Pirrie, late continental marine superintendent to the African Steamship Co. Besides the lists of single words there are translations of the various phrases used in the management of a ship both in the navigation and engineering departments. It is an up-to-date practical little book; brief yet sufficient.

The complete report of the Load Line Committee to the London Board of Trade upon the questions relative to the revision of the North Atlantic winter load-line, referred to its consideration, will be found in the New York Maritime Register of December 14, 1898. This is an important document to ship owners and others interested in over sea trade.

TRADE PUBLICATIONS.

Shipyard and other tools are thoroughly illustrated in a 9 by 12 catalogue designated as Catalogue P, just received from the Hilles & Jones Co., Wilmington, Del. Each machine is illustrated by a large half tone engraving nearly the full size of the page and the cover is printed in three colors. Every shipyard using tools for working plates, etc., should have a copy of this catalogue for permanent reference.

"The Argonaut, What she was Built for and What she has Accomplished," is the title to a very neatly printed 16-page booklet issued by the Lake Submarine Co., 11 Broadway, New York. A number of pictures are given of this unique boat showing her afloat and also performing submarine work in various ways. The purpose of the booklet is evidently to explain in considerable detail the possibilities from a business point of view of submarine investigations.

Graphite Paint.—Wm. Hooper, of Ticonderoga, N. Y., writing of the use of paints says: "If the surface to be painted is perfectly dry when finely ground graphite is applied, the paint will prove the most lasting paint known, because if time eliminates all of the oil, the graphite seems to adhere to the surface painted just the same as a piece of paper or wood will appear after it has been rubbed with a lead pencil or a piece of graphite. No other pigment known to me will remain on the surface painted after the oil has been thoroughly destroyed. With the experience I have had with graphite paint." Booklets regarding graphite paint can be had from the Joseph Dixon Crucible Co., Jersey City, N. J.

A half dozen of exceptionally handsome and valuable catalogues have been received from the Advertising Department of the Westinghouse Companies, Pittsburg, Pa., descriptive of the electrical apparatus manufactured by the Westinghouse Electric and Manufacturing Co. They are finely printed and give much statistical and other matter of value to the reader interested in electrical matters. One entitled "A Quarter Million Horse Power," describes in some detail the big electrical plant at Niagara Falls. Another is entitled "Electricity for Machine Driving," illustrating a variety of machines operated by Westinghouse motors. The third is devoted to lighting arresters, the fourth to alternating current arc lamps, the fifth to the modern roundhouse turn table, showing the application of electric motors to turn tables. The largest one of the six is Part 1, of Electric Street Railroad History. Among these catalogues must be several which would be of much value to anyone interested in electrical work, either in the shipyard or on board ship. Copies can be had upon application.

A portable hydraulic punch is illustrated in two large 8 by 10 pictures in a folder issued by the Cornell Portable Hydraulic Punch Co., 922 North Nineteenth street, Philadelphia, Pa. The features of the punch are fully set forth in the circular.

Generating sets with automatic upright and horizontal engines manufactured by the B. F. Sturtevant Co., Jamaica Plain, Mass., are illustrated by large cuts and described concisely in a large 8-page folder issued as Bulletin G. Every man interested in such matters should have a copy of this bulletin, which can be had upon application. Bulletin E, issued by the Sturtevant Co., entitled "Draft without a Chimney" was in such demand that a second edition has been issued and is now ready for distribution.

BUSINESS NOTES.

KEEL BLOCKS.—Attention is called to the new type of keel blocks illustrated in the advertisement of the Hegley Keel Block Co., 45 Fourteenth street, Hoboken, N. J.

SURFACE CONDENSERS.—Corrugated tube surface condensers from 10 sq. ft. to 2,000 sq. ft. of surface, as well as other devices of value for marine work are offered by the Taunton Locomotive Mfg. Co., Taunton, Mass. An interesting catalogue descriptive of these articles can be had upon application.

FORGINGS FOR TORPEDO BOAT DAVIS.—The torpedo boat Davis constructed by the Wolff & Zwicker Iron Works, Portland, Ore., is fitted with shafting furnished by the Bethlehem Iron Co., South Bethlehem, Pa. A large percentage of the steel forgings furnished for torpedo boats come from the works of the Bethlehem Company.

NEW MARINE RAILWAYS.—There has recently been quite a spread in rebuilding old and establishing new marine railways in Nova Scotia and New Brunswick, and H. I. Crandall & Son, 100 Border St., East Boston, Mass., have been very busy doing much of the work. The Messrs. Crandall make a specialty of marine ways, and have built many of the leading ones in this country.

ANTI-FRICTION METAL.—A new metal called the Perfect Lubricating Metal is being put on the market by the Perfect Lubricating Metal Co., Cincinnati, Ohio. The special claims are that one of its component parts is graphite, that it is considerably lighter in weight than many other anti-friction metals, and that it is a phosphorized tin. Engineers interested should send to the company for circulars and further detail.

ALUMINUM STEEL TUBING.—Something new in the tubing line is being put on the market by the Ellwood-Ivins Tube Co., 487 Broadway, New York. It is a special alloy of aluminum made into very thin seamless tubes which are drawn over steel tubing. The result is said to be tubing which has the strength and elasticity of steel with the attendant advantages of solid aluminum tubing. Full information regarding this tubing can be had upon application to the company.

THE BLOOMSBURG SPECIALTIES.—The many orders which have been placed during the past year for steam vessels have brought a large increase of trade to H. Bloomsburg & Co., Newport News, Va., who have sold more steam jets and circulators than at any time during the history of the company. These specialties can be seen in operation in almost any harbor or port in the United States, and people interested in them should send to the company for names of vessels on which they are used in order to make a personal investigation.

A FLOURISHING INDUSTRY.—The Chester (Pa.) Times, of December 16, says: "This city has an industry that is not making any noise, yet which will at no distant day be one of the most important in this city. It is the manufacture of the Baldt anchor. The anchors are made at the Penn Steel Works and though they have not been long on the market, they are in use by vessels that ply on many of the important rivers and harbors of the Atlantic coast, on steamers on the great lakes and upon ocean steamships. They have been approved by United States naval officers and seamen on all kinds of craft. The Baldt anchor is a distinct departure from the old style fluke and is a simple, but most ingenious device.

PENBERTHY INJECTORS.—Attention is called to the exceptionally fine advertising which has been done in these pages lately by the Penberthy Injector Co., Detroit, Mich., and especially to the new cut which appears in this month's issue. This company is believed to be the largest injector manufacturing company in the country if not in the world and, of course, gives every attention possible toward covering its field in the most thorough way.

HOLLOW STAY BOLTS FOR BOILERS.—Hollow stay bolts are coming into extensive use in boiler making and we are informed that the Falls Hollow Stay Bolt Co., Cuyahoga Falls, Ohio, made a recent shipment of a car load of these bolts to one of the large marine boiler manufacturers. These bolts are offered as a safe guard against failure and have unusual lasting qualities, being rolled hollow. Full information regarding these bolts can be had from the manufacturers.

Complete Lighting Plant.—The coast survey steamer Blake, which has been hauled out at Baltimore, is having a complete electric lighting plant installed by The E. G. Bernard Co., Troy, N. Y.

Engineers' Specialties.—A line of several specialties of particular interest to engineers is illustrated in a little folder issued by the American Steam Gauge Co., 36 Chardon street, Boston, Mass. They include the American Thompson Improved Indicator, the American Patent Pop Safety Valve, pressure and vacuum gauges, underwriter water and cylinder relief valves and planimeters.

Life Preservers.—The recent storm along the Atlantic coast and the unusual gales on the lakes have led to a great demand for life preservers, causing the Armstrong Cork Co., Pittsburg, Pa., to be pretty nearly swamped with orders for the best class of life preservers.

Valves.—A new line of blow off and operating valves has been put on the market by the Homestead Valve Mfg. Co., Homestead, Pa. There are several features regarding these valves which are well worth investigating. A catalogue of the company explains these in some detail.

Bearing Metal.—Engineers and others having trouble with bearings will be interested in the nickel babbit and X L C R babbitt advertised elsewhere by J. J. Ryan & Co., 68-74 West Monroe street, Chicago. This company makes a specialty of making bearings suited to special conditions.

Large Dredging Contract.—The New York Dredging Co., World Building, New York, has begun work on an extensive contract for dredging the Christiana river, Wilmington, Del. The immense hydraulic dredges will fill in adjoining marshes and reclaim a large area of property.

SPECIAL NOTICES.

Announcements under this heading will be inserted at the uniform rate of thirty-three-and-a-third cents a line. Lines average ten words each.

BOATS BUILT CHEAP.

Boat Builder on Inland Lake is satisfied with day wages during Winter. Launch, cat, or small sloop hulls contracted for now can be figured low. Address BOATBUILDER,
Care of MARINE ENGINEERING,
World Building, New York.

NEW YORK'S FINEST PLEASURE TRIP.

The finest pleasure trip out of New York harbor is by the boats which ply between New York and Hartford, Conn.

The screw steamers "Middletown" and "Hartford" are new and commodious, the meals served excellent, the trip inexpensive, and the scenery up the Connecticut River superb.

The New York Pier is 24 East River, and the boats leave each end daily at 5 P.M., except Sundays

Calendars for 1899 Received.

From the Boston Belting Co., 256 Devonshire street, Boston, Mass., a small celluloid pocket calendar, 2 by 3 1-2 in. in size.

Also from the same company a very neatly bound calendar in book form with 16 pages, the size being 1 1-2 by 2 in. Besides the calendar this book contains oiled paper divisions for carrying postage stamps, information regarding many matters, postage rates and other data.

From the Youngstown Iron & Steel Roofing Co., Youngstown, O., a calendar 13 by 20 in. in size, containing a reproduction of the famous picture "The Bride," by Bisson.

Copies of these calendars can be had up to the limit of the supply by writing to the companies and mentioning Marine Engineering.

H. P. SAFETY POCKET LIGHT.

Price each, by mail, $3.30. Extra charges, by mail, $0.50.
(OVER 10,000 IN USE.)

An ever ready Electric Light for Electricians, Engineers, Navigators, Ship Officers, Machinists, Watchmen,
and for all purposes where a safe and handy flash light is desired. Gives approximately 6,000 lights before battery requires renewal. No wires to get out of order. No chemicals to spill. Can be carried into a cellar full of leaking gas, into an oil tank, alcohol and malt vats, or placed in a keg of powder without the slightest danger of explosion. Size, 1¾ in. x 9 in. Weight, about one and one-eighth lbs. JAMES S. BARRON & CO., Manufacturers of and Wholesale Dealers in General Electrical Supplies, 24-30 Hudson St., New York.

KEUFFEL & ESSER CO.

NEW YORK.

127 Fulton and 42 Ann Sts.

Drawing Materials.
All requisites for
Marine Draftsmen.

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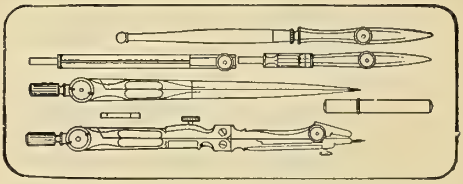

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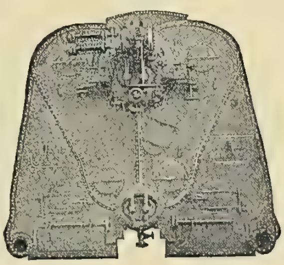

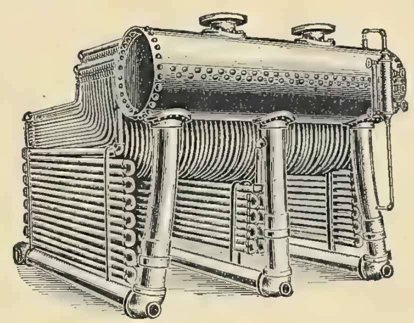

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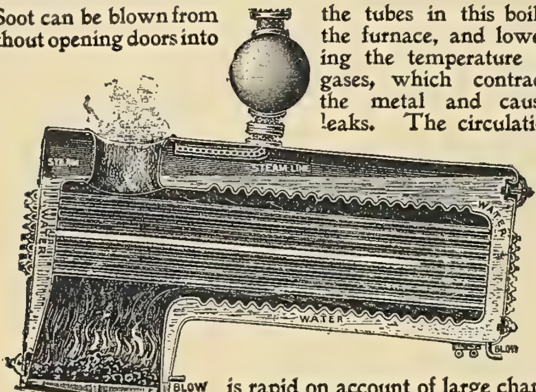

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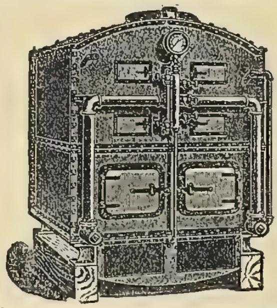

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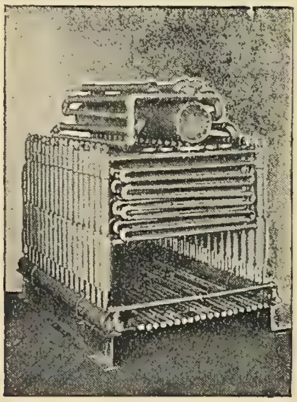

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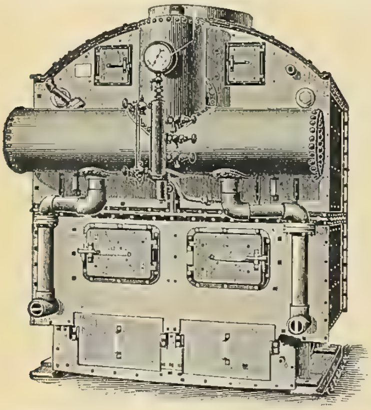

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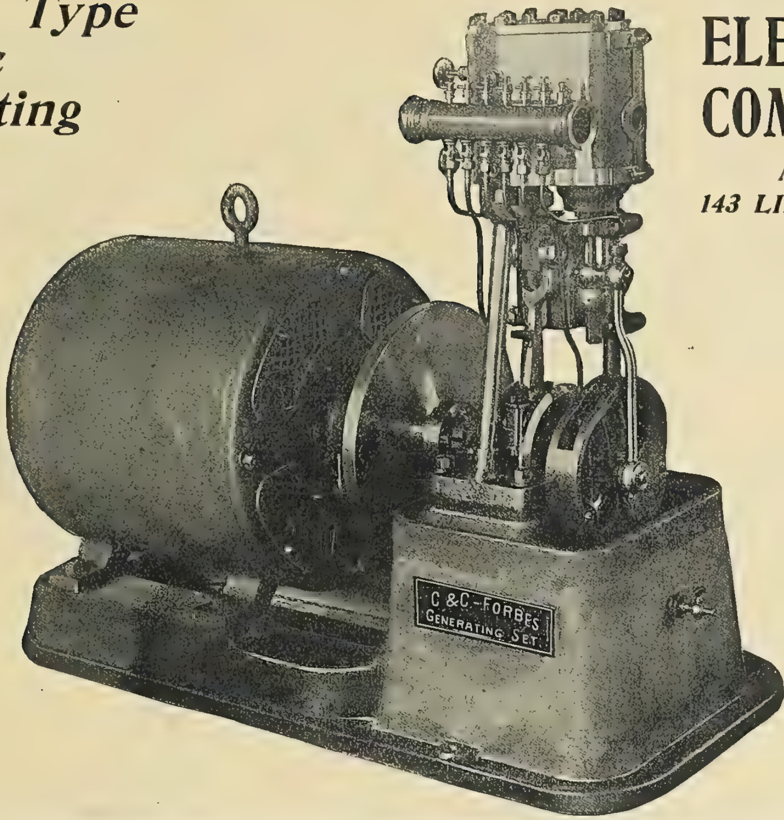

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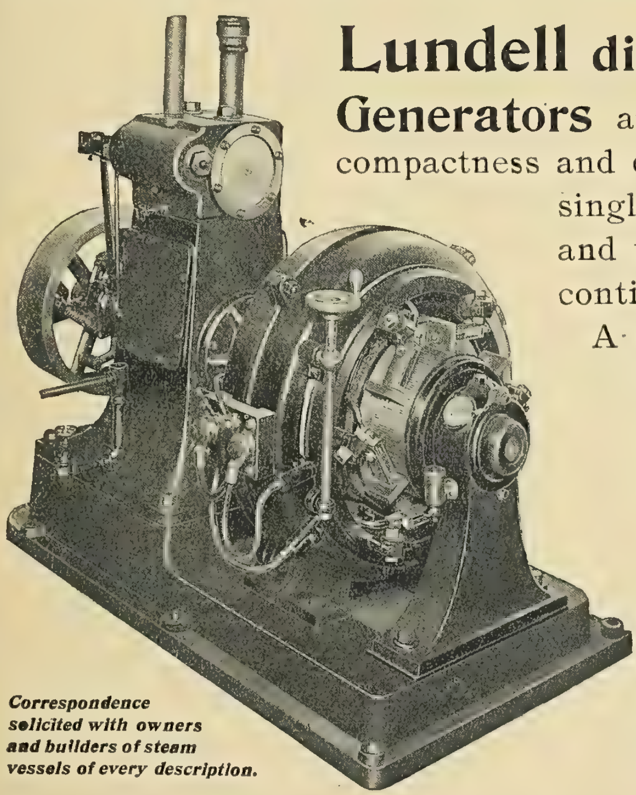

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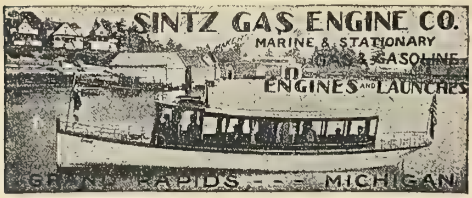

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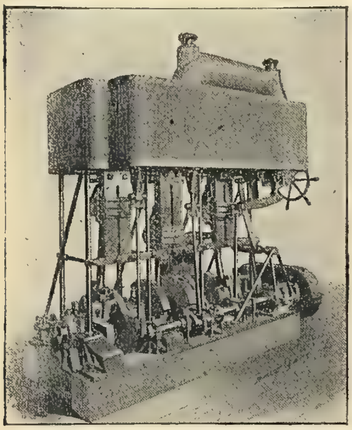

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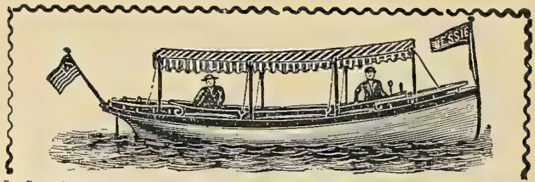

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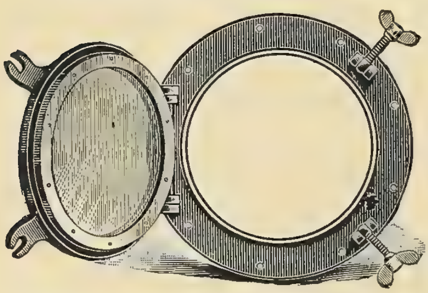

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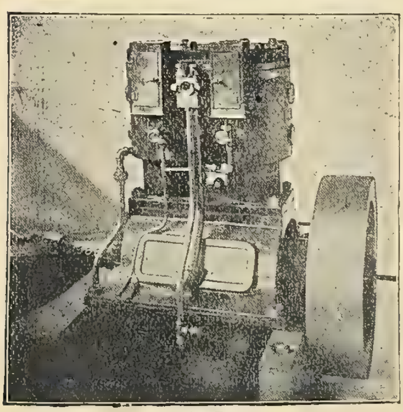

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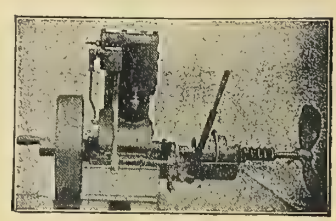

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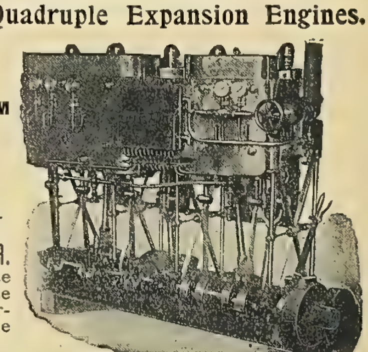

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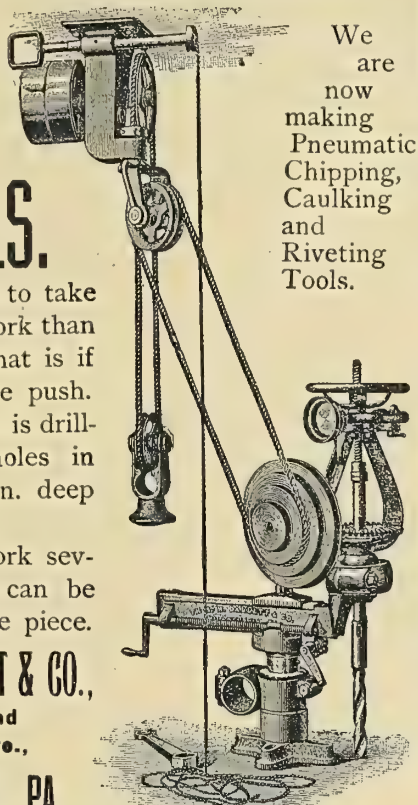

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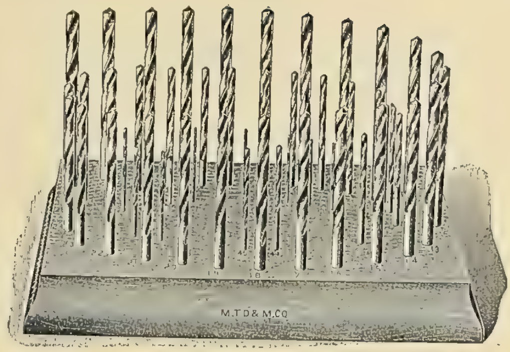

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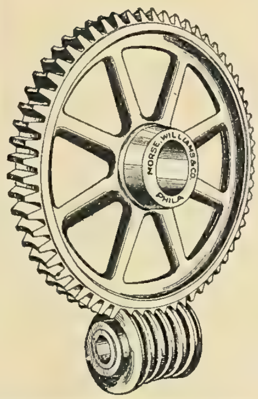

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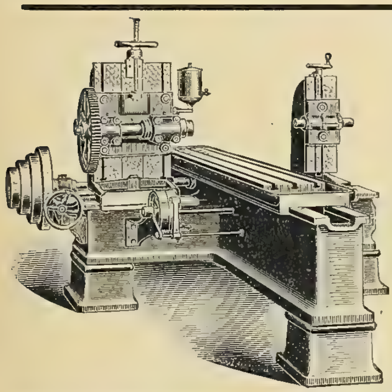

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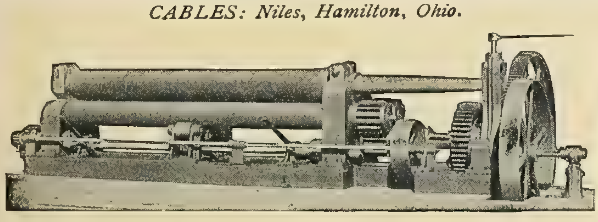

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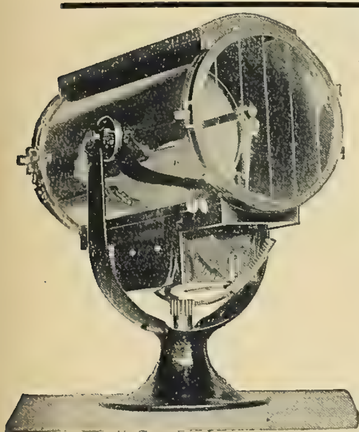

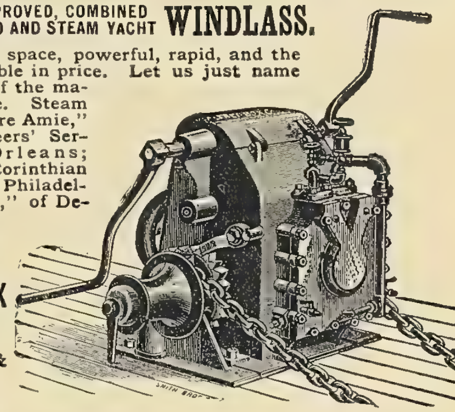

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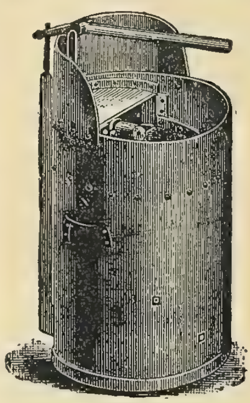

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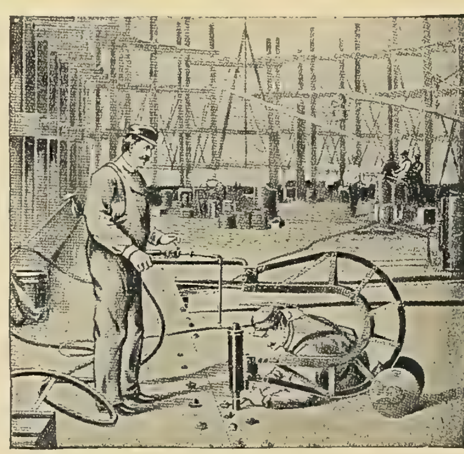

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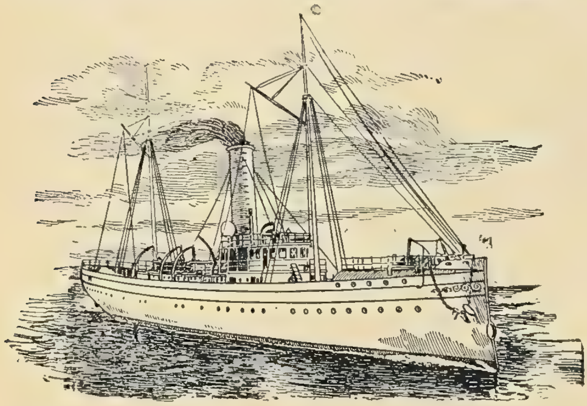

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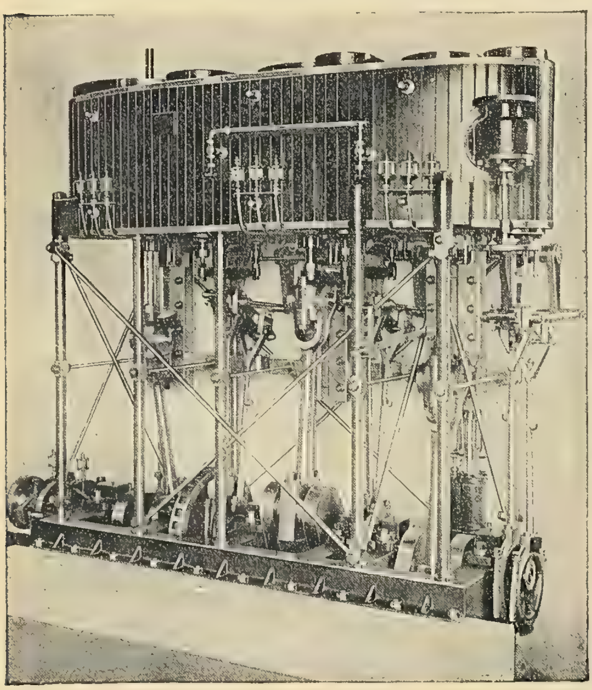

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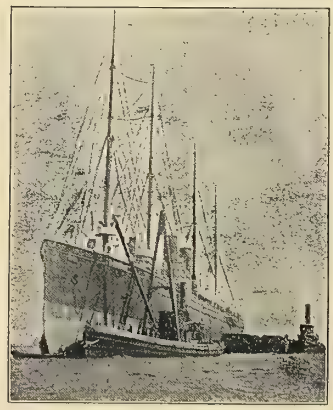

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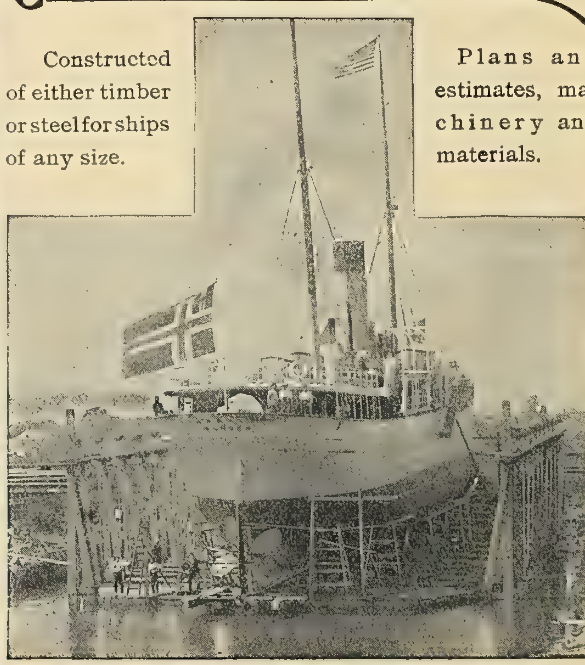

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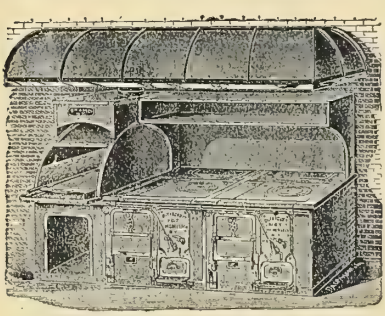

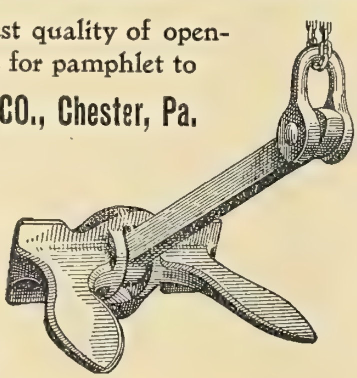

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THE MONSTER WHITE STAR LINER OCEANIC LAUNCHED AT BELFAST, IRELAND.

Our frontispiece shows the launching of the White Star Line steamship Oceanic at the yard of Harland & Wolff, Belfast, Ireland. This event took place on Saturday, January 14, so our readers will appreciate that some quick work was necessary to get the instantaneous photograph of the launch in print in this issue.

In dimensions the Oceanic exceeds any vessel afloat or built. In detail they are: Length over all, 704 ft.; length between perpendiculars, 685 ft.; beam, 68 ft.; depth moulded, 49 ft. 6 in.; extreme depth, 68 ft.; load draught, about 32 ft.; gross tonnage, 17,040 tons; maximum displacement, about 30,000 tons. She is designed to maintain a sea speed, day in and day out, of 20 knots, and to be capable of an average rate of 21 knots if let out.

The speed decided upon is less than that of other vessels now in the trade and considerably less than that of the 23-knot vessel under construction for the Atlantic trade for one of the German lines. The new vessel will be rather speedier, however, than the two largest ships of the line now in service, the Teutonic and Majestic. On account of the moderate speed demanded the engine power will be less than

WHITE STAR TWIN-SCREW S.S. OCEANIC LEAVING THE WAYS AT HARLAND & WOLFF'S.
(*Photographed for Marine Engineering by Geo. M. Roche, Esq.*)

that of the big Cunarders, Campania and Lucania. It is estimated at 28,000 I. H. P. divided into two sets driving twin screws.

In general appearance the Oceanic will follow the lines of the Teutonic and Majestic. She will have three pole masts and two large elliptical stacks. She will have also a straight stem and an elliptical stern and will have a pleasing amount of sheer. She will not be fitted with turtle back decks forward and aft as in other ships of the line, for the ends will be so high that these will be unnecessary. She will have seven decks, five of which are carried from stem to stern and all of them designed to add to the strength of the vessel. These are in order: Lower orlop deck, orlop deck, lower deck (which will be about the water line), middle deck, upper deck, promenade deck and boat deck. Surmounting this in front of the forward funnel, over the pilot house, there will be the navigating bridge. The photographs published herewith give a very clear idea of the hull design. It will be noticed that the forefoot is cut away and that the vessel is very fine aft and that there is a screw opening in the deadwood, as is usual in twin screw vessels built at this yard. This permits of the propellers being placed close to one another, and at the same time gives better opportunity for the water to reach the blades. The propeller shafts and the stern brackets are enclosed by the skin plating. The vessel will have twin screws, driven by inverted triple-expansion four-cylinder, four-crank engines, with cylinders; H. P. 47 1-2 in.; I. P., 79 in., and two L. P. 93 in., all with 72 in. stroke. Piston valves will be fitted to the H. P. and I. P. cylinders and double-ported valves to the L. P. cylinder. Independent cylindrical condensers will be used and the air pumps will be driven from the L. P. crossheads in the usual way. Stephenson link motion will be used. Great care has been taken in putting the very highest class material into the vessel. The crank shafts will be fluid compressed steel, built up, 25 in. dia. in the bearings and 26 in. in the pins. Line shafts will be 23 3-4 in. dia., and propeller shafting 25 1-4 in., all of which will be hollow. The propellers will have gun metal hubs and detachable manganeze bronze plates, three blades to each propeller. The diameter will be 22 ft. 3 in. The boilers will be of the regular cylindrical double-ended fire tube type, placed in groups athwartships, the largest of them having diameter of 16 ft. 6 in.

With the launch of a vessel of this class comes the inevitable comparisons with her predecessors. The vessel in this case with which a comparison most naturally follows is the Great Eastern, launched in 1858 and long ago gone to the scrap heap. Her dimensions were: Length, 692 ft.; beam, 82 ft. 6 in.; depth, 58 ft., and gross tonnage, 19,000 tons. She was fitted with both paddle and screw engines of about 8,000 aggregate horse power, and had a sea speed of about 13 knots. In recent days the vessels for direct comparison can be taken from the Cunard and North German Lloyd fleets. Of the former, the Campania is in length 620 ft., beam 65 ft., and 12,950 gross tons; while the Kaiser Wilhelm der Grosse is in length 648 ft., beam 66 ft., and 14,000 gross tons.

VIBRATIONS OF STEAMSHIPS AND METHODS OF BALANCING MARINE ENGINES—I.

BY C. H. PEABODY, B. Sc.

All steamships tremble or vibrate more or less when the engines are running. It is only when the vibrations are excessive that the trembling attracts attention, and as this usually occurs when a powerful engine is placed in a lightly built ship, it has been commonly considered that the trembling is due to weakness of the hull. Should the hull be strengthened in accordance with this idea the trembling will probably be reduced, which naturally is considered as a confirmation of the assumed reason for the trembling. Yet some lightly built ships which are driven by powerful engines do not tremble excessively, and, on the other hand, some strong ships vibrate violently; and, again, a ship may vibrate violently, and even dangerously, at some speeds and be fairly quiet at other speeds. Thus the U. S. cruiser Columbia on her trial trip showed a very disagreeable amount of vibration when running at about 19 knots, but was noticeably quiet at full speed. The greatest difficulty has been experienced from vibrations of torpedo boats, in which high speed is sought by the combination of powerful high speed engines in light and slender hulls. Such boats are liable to vibrate excessively at several speeds, such as half speed, three-quarter speed and full speed, and at intermediate speed the vibration may be of little importance.

These facts point to the true explanation of the cause of vibration of the hull of a ship, namely, the coincidence of the time of revolution of the engine to the natural time of vibration of the hull. For the hull of a ship, especially of an iron or steel ship, is an elastic body with a natural time of vibration; just as a steel rod or a tense cord has a natural time of vibration, which can be recognized by the musical note emitted when the rod or cord is struck. The time of vibration of a rod depends upon and can be calculated from its form and dimensions and its weight and elasticity. And in like manner the time of vibration of the hull of a ship depends on its size and form, and on its construction and the distribution of the weights carried, such as the weight of the hull, the machinery and equipment and the cargo or other burdens carried. The structure of the hull is so complicated and the distribution of the weights is so irregular that no one has ventured to make a theoretical discussion of the time of vibration of a ship. But the fact that a ship may in a general way be likened to a beam or girder allows us to establish certain semi-logical equations which can be used to estimate the probable time of vibration of a ship from the observed time of vibrations of ships of the same class.

To make this matter clear it is necessary to look somewhat closely into the vibrations of bodies that are carried or supported on springs. For example, the time of vibration of a wagon body depends on the stiffness of the springs and on the weight of the wagon body and the load in it. But the deflection of the springs is a measure at once of the stiffness of

T. S. S. OCEANIC FULLY WATERBORNE.

T. S. S. OCEANIC ALL CLEAR READY FOR LAUNCHING, JANUARY 14, 1899.
(*Photographs taken for Marine Engineering by Geo. M. Roche, Esq.*)

the springs and of the load on them, so that the number of vibrations per minute can be determined as soon as the deflection is known. If the deflection of the spring in feet is d, then the time of a single vibration in seconds is

$$t = \pi \sqrt{\frac{d}{g}}$$

when $\pi = 3.1416$ is the ratio of the circumference of a circle to its diameter and $g = 32.16$ is the acceleration due to gravity, or the distance a body will fall freely from rest in one second.

Now a girder or beam when loaded may act as a spring, and its deflection will be proportional to the load on it; but it is also affected by the length and other dimensions of the beam, thus the deflection is proportional to the cube of the length of the beam and is inversely proportional to the moment of inertia of the cross section of the beam. The last term, *moment of inertia*, is one that is developed in the theory of beams. To express these facts in a formula we may write

$$d \propto \frac{W L^3}{I}$$

when W is the load on the beam, including its own weight, L is the length of the beam, and I is the moment of inertia. Replacing the deflection in the general equation for the time of vibration of a spring by the form just written, we have

$$t \propto \sqrt{\frac{W L^3}{I}}$$

Applying this to the time of vibration of the hull of a ship, which can be likened, as has been said, to a beam or girder, we will find that W, the weight, may be replaced by the displacement of the ship in tons, that L is the length of the ship in feet and that I is the moment of inertia of the midship section. It will be sufficient to note that for the present purpose the moment of inertia may be calculated by multiplying the area of the section of each longitudinal member of the ship (such as keel, stringer, shell plate or deck plate) by its distance from the neutral axis of the midship section.

Following such a line of reasoning, both Normand and Schlick have independently proposed the following formula for calculating the time of vibration of a ship:

$$N = C \sqrt{\frac{I}{D L^3}},$$

in which

N = number of single vibrations per minute.

D = displacement in tons.

L = length in feet.

I = moment of inertia of midship section (areas in square inches, distances in feet).

C = a constant, depending on the class of the ship.

Schlick gives the following values for the constant C:

Torpedo-boat destroyers..........	$C = 156850$
Large passenger steamers.........	$C = 14350$
Cargo boats......................	$C = 12790$

Schlick further asserts that any ordinary variation in the distribution of weights has little effect on the value of the constants. But a concentration of weights either at the ends or at the middle of a ship will give slower vibration, since such a concentration leads to a greater bending or deflection of the hull of the ship on account of the manner of loading.

A notable example of the change of time of vibration of a ship came under the attention of the writer. A certain screw ferryboat was built with fuller lines at the ends than was intended. The consequence was that the boat floated too high and the deck at the ends was a foot or more higher than the floats of the slips at the landings. To bring the boat down, about 300 tons of stone ballast were placed in the ends of the boat, which so decreased the number of vibrations per minute as to bring about a close coincidence with the time of rotation of the engine and dangerous vibrations ensued. The difficulty was overcome by removing the ballast and lowering the deck at the ends.

The vibrations thus far considered are vertical vibrations of the whole structure of the ship, which may be likened to the vibrations of a thin plate. Fig. 1 represents the simplest form of vibration of such a thin plate, on an exaggerated vertical scale. $a\ c\ b$ represents the neutral position of the plate when at rest, and $a'\ c'\ b'$ and $a''\ c''\ b''$ represent extreme positions when vibrating. At certain points,

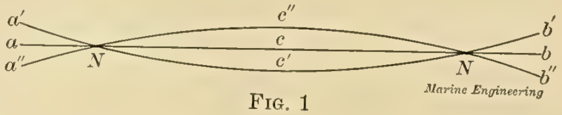


Fig. 1

N and N, near the ends, there is no vibration; such points are called nodes. The place where the vibration is greatest is known as a loop. The nodes of a thin plate of uniform section are somewhat less than a quarter of its length from the ends. The location of the nodes of vibrations of ships have not been well located. Schlick gives the following as the location of nodes of fast cruisers and dispatch boats:

Forward node—0.310 to 0.365 of length aft of forward perpendicular.

Aft node—0.231 to 0.365 of length forward of aft perpendicular.

Fig. 1, with two nodes and one loop, represents the simplest and slowest vibration that can be given to a plate or a rod. A rod which is supported at the nodes can be set into vibration by striking it with a light hammer or mallet, or by drawing a fiddle bow across it. If the rod is supported at three points or nodes, one at the middle and two nearer the ends, it can be made to vibrate with two loops; the vibrations will then be more rapid. Again, a rod may be made to vibrate with four nodes and three loops at still a higher rate, and so on. In like manner a ship may be set into vibrations of a higher order and of greater frequency with three or four nodes and two or three loops. Such vibrations are much less easily set up and are less dangerous than the simple vibrations with two nodes; consequently our attention will be given mainly to the simplest vibrations.

In addition to the vibrations of the entire structure of the ship, there are certain local vibrations which may occur, and which must not be confused with the vibrations of the hull. As examples of local vibrations we may instance panting near the bow or stern, where the shell plating is but little curved; vibrations at or near the rudder post and vibrations under the engine.

The general form of the hull of a ship is so rounded and reinforced by the transverse framing as to be stiff and rigid. But near the bow the surface is flatter and is likely to be affected by the varying pressure of the water as the ship pitches among waves. The flat surface, if not stiffened by special construction, is likely to spring out and in; such action is called *panting*, and can be prevented by working in an additional longitudinal stringer between the usual longitudinal members which extend throughout the length of the ship. The panting stringers on the two sides of the bow may be reinforced by tying them together, or better, by working a flat or deck on them. Panting may also occur near the stern, but in general the form of a ship near the stern is less likely to be affected by panting.

The whole structure of the frame of a ship near the rudder post is weak transversely, due to fining away the hull so that water can flow freely to the propeller and the rudder. Should the propeller be out of balance dangerous vibrations may be set up near the stern post, especially if the natural time of vibration of the thin and flattened structure between the keel and the rudder post coincides nearly with the time of revolution of the engines. There is, however, no excuse for lack of balance of the propeller and its shaft, and such vibrations are not of importance on well built ships when steaming ahead on a straight course. But when a ship is turning the propeller blades on the outer side of the curved course reach out into undisturbed water and meet with greater resistance than the blades at the inside, which work in the wake of the ship. The fluctuation of pressure exerted by a propeller blade which works now in undisturbed water and again in the wake gives rise to a vibration of the stern of the ship which may be dangerous when the helm is thrown hard over at full speed. There is, of course, no remedy for this; fortunately there is seldom necessity for turning sharply at full speed.

Some shallow draught vessels with quick running engines have shown a serious vibration of the bottom of the hull directly under the engines. This vibration, which is like that of a tense membrane—for example, the head of a drum—is like the vibration of the hull in general, in that it is due to a coincidence of the time of vibration of the bottom framing and plating with the time of revolution of the engine. It can be prevented by stiffening the bottom framing and so increasing the number of vibrations per minute. But as the natural method of stiffening the framing is to increase the depth of the floors, it may be difficult to provide for such stiffening. If the engine foundation is deficient in strength it may yield to the forces exerted by the engine; such a movement of the engine should not be confused with vibrations of the bottom of the hull.

Returning to the vibrations of the whole structure of the hull of a ship, which vibrations are at once more common and more difficult to deal with, it is necessary to show the true course of these vibrations. They are not due to the direct pull and thrust of the steam pressure working on the piston, for these direct forces are taken up by the engine frame, but they are due to the reciprocation of the moving parts of the engine, such as the piston, piston-rod, crosshead and connecting-rod. These parts are at rest at the beginning of a stroke, and can be set in motion only by the action of an unbalanced force. This force comes of course from the steam pressure on the piston and must be subtracted from the total force of the steam in order to find the effective force which is applied to the crank pin and turns the crankshaft. The effective force is taken up by the engine frame, but the unbalanced force is resisted by the framing of the ship. It will be noted that the force required to accelerate the piston and attached parts is independent of the steam pressure and of the work done by the steam in the cylinder. This force depends on the weight of the reciprocating parts, on the length of the stroke, and on the number of revolutions per minute. The vibrations will then be the same for the same speed of the engine, whether it is running under full load, as when driving the ship at full speed; whether it is running light, for example, with the propeller removed, or whether it is rotated by some external power applied to the shaft, if that is possible. The accelerating force is greatest at the beginning of the stroke, diminished until it is zero near the middle of the stroke, and then changes into a resistance which brings the piston to rest at the end of the stroke. The calculation of the accelerating and retarding forces which produce the vertical motion of the reciprocating parts of the engine is somewhat tedious, but presents no particular difficulty, if properly systematized, and should be made for all high speed engines in the determination of the strength of the engine.

Note. The displacement of the piston from the beginning of the stroke in Fig. 2 is;

$$A\,B = A\,E + E\,O - B\,D - D\,O$$

$$= A\,E + E\,O - \sqrt{\overline{BC}^2 - \overline{CD}^2} - DO.$$

If $B\,C = l$ = length of connecting rod;
$C\,O = r$ = length of crank;
$A\,B = s$ = displacement of the piston,
and $C\,O\,D = a\,t$ = crank angle; then

$$s = l + r - \sqrt{l^2 - r^2 \sin^2 a\,t} - r \cos a\,t.$$

Here a is the angular velocity of the crank, that is the angular

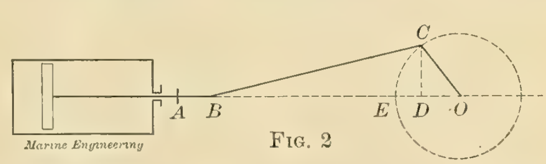


FIG. 2

space swept over in a second, and can be calculated by the expression

$$a = \frac{2\,\pi\,N}{60}$$

when N is the number of revolutions per minute.

The velocity of the piston at any position s from the beginning of the stroke is;

$$v = \frac{d\,s}{d\,t} = \frac{a\,r^2 \sin a\,t \cos a\,t}{\sqrt{l^2 - r^2 \sin^2 a\,t}} + a\,r \sin a\,t$$

$$\therefore v = a\,r \sin a\,t \left\{ 1 + \frac{r \cos a\,t}{\sqrt{l^2 - r^2 \sin^2 a\,t}} \right\};$$

and the acceleration is

$$f = \frac{d^2 s}{d\,t^2} = a^2\,r \cos a\,t \left\{ 1 + \frac{r \cos a\,t}{\sqrt{l^2 - r^2 \sin^2 a\,t}} \right\}$$

$$+ a\,r \sin a\,t \left\{ - a\,r \sin a\,t\,[l^2 - r^2 \sin^2 a\,t]^{-\frac{1}{2}} + r \cos a\,t\,[(l^2 - r^2 \sin^2 a\,t)^{-\frac{3}{2}}\,(a\,r^2 \sin a\,t \cos a\,t)] \right\}$$

$$\therefore f = a^2\,r \left\{ \cos a\,t + \frac{r\,(\cos^2 a\,t - \sin^2 a\,t)}{\sqrt{l^2 - r^2 \sin^2 a\,t}} + \frac{r^3 \sin^2 a\,t \cos^2 a\,t}{(l^2 - r^2 \sin^2 a\,t)^{\frac{3}{2}}} \right\}$$

If the connecting rod is very long compared with the crank, or better still, if the engine has a slotted crosshead, then the velocity and acceleration become,

$$v = a\,r \sin a\,t$$

$$f = a^2\,r \cos a\,t$$

If W is the weight of the reciprocating parts and g is the acceleration due to gravity, then the force required to produce the motion of the reciprocating parts is

$$F = f\,\frac{W}{g}$$

The method of calculating the forces required to produce the motion of the reciprocating parts, i. e., the piston, piston-rod, crosshead and connecting-rod, is given in the preceding note. It will now be sufficient to note that the force is less at the lower or crank end than it is at the upper or head end of a vertical marine engine; this fact will become of importance in the consideration of certain methods of balancing engines.

The action of the fluctuating forces which produces the motion of the piston and attached parts of a single cylinder engine may be likened to a man standing on his toes and teetering up and down. If a man stands thus at the middle of a plank which is supported at the nodes (N and N, Fig. 1) he may readily throw the plank into violent vibration. In like manner a single cylinder engine placed at the middle of a ship may produce dangerous vibrations. If such an engine is placed at a node, that is at about a quarter of the length of the ship from the stern, it can have little effect in producing vibration.

Suppose now that an engine has two cylinders placed side by side, and with the cranks opposite, similar to the high-pressure and intermediate cylinders of Fig. 6, and that the weight of the reciprocating parts is the same for each cylinder. Then there

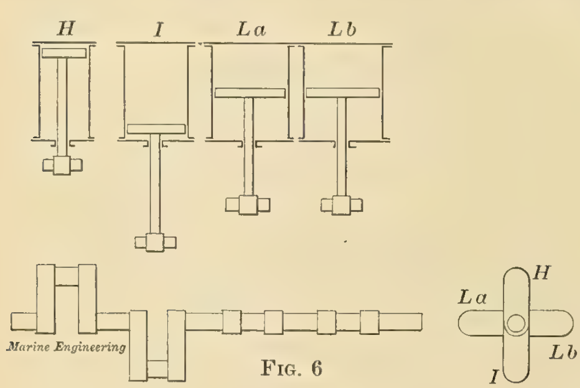


FIG. 6

will be very nearly a balance of the vertical forces producing motion of the piston, for one piston will be coming up as the other is going down. The balance would be exact if the engine had slotted crossheads; with short connecting rods commonly used on marine engines the force for the piston starting down will be considerably larger than for the piston which is going up. Nevertheless such an engine placed at the middle of a ship would produce very little vibration. Since the turning moment which such an engine would exert on the crankshaft would be as irregular as that of a single cylinder engine, two-cylinder engines with opposite cranks have never been used to propel ships. When that device has been used for balancing engines four cylinders have been used, as will be explained later in connection with Fig. 6.

Suppose that such an engine with two opposite cranks were placed at the node of a ship, so that one cylinder is as much ahead as the other is aft of the node; its action may be likened to that of a man standing astride of a node of a plank and throwing his weight now on one foot and then on the other. By such action he could readily throw the plank into vibration, and so also will the engine produce violent shaking of the ship when at or near a node. This engine is sometimes said to be in standing balance, but not in running balance, because it tends to rock its foundation when running.

It consequently appears that there are two ways in which a ship may be thrown into simple vibrations, like Fig. 1, with two nodes and one loop, i. e., either by an unbalanced engine at a loop (that is near the middle), or by an engine which is in standing but not in running balance, and which is at or near a node.

The ordinary three-cylinder triple-expansion engine with the cranks at 120 deg. is neither in standing nor in running balance. Schlick says that if the weight of the low pressure piston and its piston-rod, crosshead and connecting-rod is taken as unity, then the weight of the corresponding parts for the intermediate cylinder is 0.82, and for the high pressure cylinder is 0.73. It seems, therefore, that it would not be difficult to put such an engine into standing balance by adding to the weight of the intermediate and high pressure pistons. The questions arises whether it is worth while to add sufficient weight to the engine for this purpose. In the first place it is evident that it will not be worth while for a slow running engine, for such an engine will not produce much vibration in any case, and the three cranks equally spaced around the circle will give a very even turning effort on the crankshaft. For slow and moderate speeds the three-crank triple engine has a deserved good reputation for smoothness of action; three-crank compound engines with two large and one small cylinder were used successfully in large ships like the Cunarder Etruria before triple engines were introduced.

If a three-crank triple engine with the usual proportion of parts should be placed at the middle of a ship, then the lack of standing balance may give rise to serious vibrations, which could be much reduced, if not eliminated, by making the weights of the pistons equal. But engines are seldom placed in the middle of a ship, and such a balancing of the engine for that purpose is seldom called for.

The engine is usually somewhere near a node, and then it will be a question whether or not advantage will come from equalizing the weights of the piston. If the weights of the reciprocating parts have the proportion given by Schlick, namely,

Low pressure piston, piston-rod, crosshead and connecting-rod......................1
Intermediate piston, piston-rod, crosshead and connecting-rod....................0.82
High pressure piston, piston-rod, crosshead and connecting-rod....................0.73

then, as pointed out by him, there will be very small vibration due to rocking couples when the engine is placed forward of a node, as shown by Fig. 3, with the cylinders arranged in the customary order, pro-

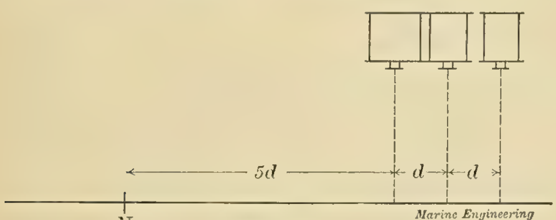


Fig. 3

vided that the axis of the low pressure cylinder is five times the common distance between the axis of the cylinder, as shown by that figure. If this is so, the moment of the weight of the reciprocating parts for each cylinder, with regard to an axis through the node, will be

$$5\ d\ W,$$

where d is the common distance between the axis of the cylinder and W is the weight of the reciprocating parts of the low pressure cylinder. This is evident from the following:

Low-pressure cylinder....$5\ d \times \quad W = 5 \quad d\ W$
Intermediate cylinder ....$6\ d \times 0.82\ W = 4.92\ d\ W$
High-pressure cylinder ...$7\ d \times 0.73\ W = 5.11\ d\ W$

Note. To show that this equality of moments will avoid rocking couples, we may bear in mind that the acceleration for harmonious motion, as has already been shown, is

$$f_3 = a^2 r \cos a\, t = a^2 r \cos A$$

where A is the angle the crank makes with the line of dead points as shown by Fig. 4, for the low pressure cylinder. The intermediate crank may be 120° ahead, as at I, and the acceleration of its piston will be

$$f_2 = a^2 r \cos (A + 120°).$$

The acceleration for the high pressure piston will be

$$f_1 = a^2 r \cos (A + 240°).$$

Expanding and reducing we have

$$f_3 = a^2 r \cos A$$
$$f_2 = a^2 r (\cos A \cos 120° - \sin A \sin 120°)$$
$$f_1 = a^2 r (\cos A \cos 240° - \sin A \sin 240°).$$

But both cos 120° and cos 240° are equal to − sin 30°, while sin 120° = cos 30° and sin 240° = − cos 30°; so that our equation becomes,

$$f_3 = a^2 r \cos A$$
$$f_2 = a^2 r (-\sin 30° \cos A - \cos 30° \sin A)$$
$$f_1 = a^2 r (-\sin 30° \cos A + \cos 30° \sin A).$$

The accelerating force for the low pressure cylinder is $f_3\, W$ and the moment of the force about an axis at the node is $5\, a f_3\, W$. The moments of the force for the other cylinder is found in a similar way, taking account of the weights of the reciprocating parts and the distances of the cylinders from the nodes. Carrying through

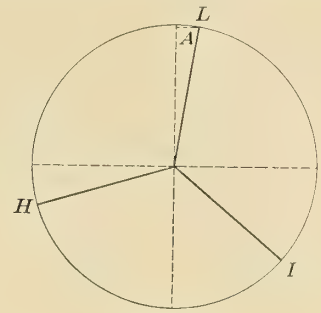


Fig. 4

this work and remembering that cos 30° = ½ we shall have for the moments for the three cylinders (or rather for their reciprocating parts)

$$5\ d\ W f_3 = 5\ d\ W a^2 r \cos A$$
$$6\ d \times 0.83\ W f_2 = 4.91\ d\ W a^2 r (-\tfrac{1}{2} \cos A - \cos 30° \sin A)$$
$$7\ d \times 0.72\ W f_1 = 5.11\ d\ W a^2 r (-\tfrac{1}{2} \cos A + \cos 30° \sin A).$$

The sum of these three equations is very nearly zero, consequently there will be very little influence at the node to produce shaking or vibration. Of course the same result would have come out if any other of the cranks had been taken at the angle A with the line of dead points.

It thus appears that the condition necessary in order that a three-crank engine (with the cranks at 120 deg.) may not produce shaking when placed near a node, is that the moment of the weight of each of the reciprocating parts with regard to an axis at the node shall be the same. If this method of avoiding vibration is to be used, then the location of the nodes of a projected ship must be known, and the location of the engine with regard to the node must be under the control of the designer. Neither of these conditions can be counted upon by a designer, for the location of the nodes is not well known and the location of the engine is commonly controlled by the necessity of trimming the ship. When the location of the nodes of ships has been determined, this method of avoiding vibration may be valuable in some cases, especially as the designer may control the moments of the reciprocating parts to some extent by loading the lighter pistons and by the spacing of the cylinders. At any rate it offers an explanation of the disappointment of some engineers who have obtained a standing balance for a three-crank engine by making all three pistons of equal weight; as the engine is likely to be near a node, such an arrangement may give worse rather than better results, so far as vibrations are concerned.

The Cramps are now figuring on a 700 ft. dry dock on their Kensington property at Philadelphia.

A bill for the construction of the Nicaragua Canal has passed the House of Representatives at Washington.

The U.S. cruiser Albany was successfully launched at the yard of Armstrong, Whitworth & Co., Newcastle-on-Tyne, Eng., January 14. The vessel is a sister ship of the New Orleans, which made a very good record during the Spanish war.

PORTABLE PNEUMATIC RIVETERS AS USED BY THE CHICAGO SHIPBUILDING COMPANY.*

BY W. I. BABCOCK.

In 1893, in a paper on shipyard appliances, read before the Engineering Congress at Chicago, Professor Durand said: "Among the various mechanical aids which would be of distinct value to the shipbuilder, few would stand higher or be more acceptable than one which would efficiently replace the ship riveter's gang."

As the result of three years of constant experimenting, into which the Chicago Shipbuilding Company was forced by the unreasonable demands and frequent strikes of its riveters, the problem has been entirely solved. We are able to drive every rivet in a ship by power machines, operated by unskilled labor, and in the last ship we have built over 250,000 have been so driven out of 340,000. But that our air capacity was insufficient, the proportion would have been greater. This paper is intended as a history of our experience in developing the portable machines.

When we began, we had already for some months been using with great success a stationary steam riveter of the ordinary type, with a horizontal ram and a 5 ft. gap, for certain portions of the work, which could be easily brought to the machine. This would include the floor plate with brackets, bilge frames and longitudinal stiffeners, as well as the side frames and belts amidships with the beam brackets thereon, and, generally, any portion of the vessel which can be riveted up and carried to the ship in one piece. The handling at the riveter is done by a chain hoist working on an overhead trolley. With this machine we have driven over 1,800 rivets in a day of 10 hours at a cost of not over 1-2 cent apiece, or a saving of 2 1-4 cents each over the scale rate for driving such rivets by hand.

In fixing first upon the power to be used for portable machines, we naturally and promptly decided upon compressed air. We were, of course, aware that hydraulic riveters had been used for years in England to a greater or less extent, and somewhat also in this country, but we were afraid that the severe winter climate of Chicago might operate against them. The more important consideration, however, was that air could be used for caulking and chipping hammers and drills or reamers, so that a compresser plant for the yard was a necessity in any event, and we did not want to go to the expense of an hydraulic plant in addition if it could be avoided.

As naturally, also, seeking for portable riveters, we first applied to the manufacturers of the compression bow machines so extensively used in bridge shops, and finally found one maker who guaranteed the performance of a machine with a horse-shoe frame having a gap of 72 in., which we needed to drive the bottom rivets in a 6 ft. center keelson. This was a matter of some difficulty, as the gap usually used was not more than 42 in., and, in fact, the first machine furnished us, in February, 1896, proved too light for the work and had to be replaced by a heavier one, the weight finally reaching over 2,500 lb. A similar tool, with the gap cut down to 45 in., weighed over 1,700 lb., and a very little experience showed that even with this lighter weight the difficulty of handling was too great to permit of the economical use of this kind of a machine for more than a very small portion of the ship.

In the spring of 1896 we heard that at the works of the Lassig Bridge and Iron Company, in Chicago, some experimental rivets had been driven with an ordinary pneumatic caulking hammer. Trying this at once in our yard, we found the method perfectly feasible, though severe on the man using the hammer. It was also almost impossible to hold on to the rivets by the ordinary heavy hammer, the blows of the pneumatic hammer on the point being so heavy and continuous that the holder-on was unable to keep his hammer from being fairly "jarred" off the head of the rivet. This difficulty, however, was quickly obviated by the use of a pneumatic holder-on which we devised, of the simplest construction, being only a cylinder into which air is admitted, forcing out a piston, the rod of which is cupped out to go over the rivet head. The parallel arrangement of the longitudinals in the double bottom of our lake ships made it easy to obtain a bearing or resistance for the cylinder itself, a piece of pipe of the proper length being screwed to it. This made a perfectly practicable method, and many rivets were driven by it. We still use it to some extent for odd rivets or in certain contracted spaces.

The next step was naturally the connection of the hammer and holder-on by a horse-shoe frame or bow, forming a single machine. As the bow has only to resist the pressure of the holder-on and the blows of the hammer, it can be made of very light construction and is very easily handled and moved to various parts of the ship. Nearly all of the inside rivets in our ships are now driven by these machines.

A variation in the device is to mount the hammer itself as a piston in a cylinder, to which air is admitted to force out the hammer as the point of the rivet is beaten down, using a plain die on the other side, which die can, therefore, be made small to get into contracted places.

The weights of the whole arrangement for various depths of gap, taken from actual machines in use in our yard, are as follows: 9 in., 83 lb.; 51 1-2 in., 160 lb.; 70 in., 220 lb. In the larger ones the bow is made of a plain piece of wrought-iron pipe.

In some cases the riveter is suspended by a chain hoist from a trolley carried on a beam supported by a pair of A frames. As a general rule, however, the whole machine is so light that it is easily moved around by hand. A wooden roller may be fitted on the cross brace to facilitate moving the riveter along a center keelson or girder.

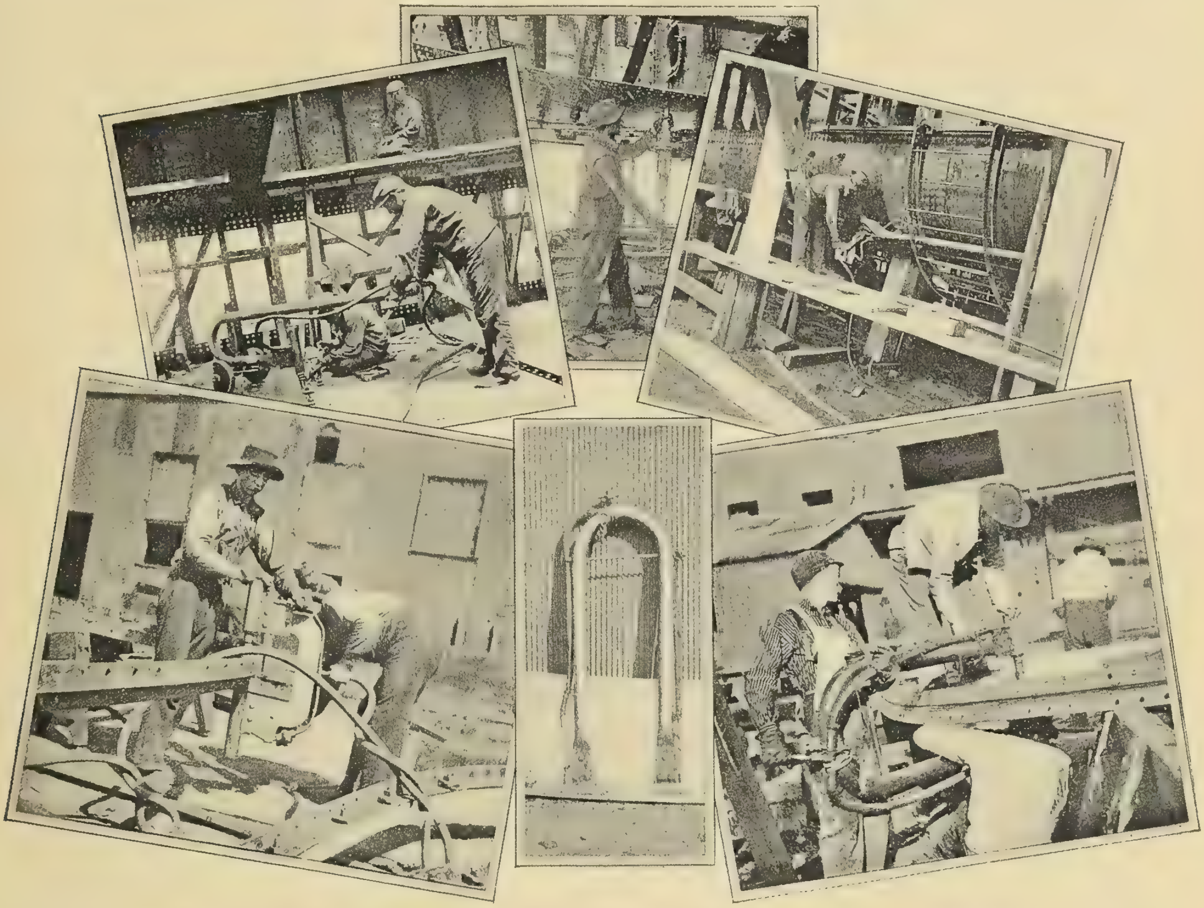
That these machines can and do make better work than hand riveting is evident from several considerations. It is well known that in hand work constant watchfulness is required to make the men properly "plug" the rivet before heading over the point; that is, to strike the first blows exactly in line with the axis of the rivet so as to upset it clear to the head and make it properly fill the holes; it is much easier and quicker

*A paper read at the Sixth General Meeting of the Society of Naval Architects and Marine Engineers.

for the men to knock the head over at once, and when that is done, as the head and point look all right, there is no way of determining in what condition the body of the rivet is, unless it is loose under test, or loosens up in service afterward with the constant vibration and jar of the ship, as often happens. With the machine, however, it is almost impossible not to plug the rivet, the hammer being very easily and naturally brought in line with its axis, and, in fact, will not drive the rivet properly unless it is so in line, and the blows of the hammer being so rapid that the plugging is accomplished before the point is formed. The whole operation of driving the rivet is completed much more quickly than by hand, and before the rivet has lost its heat, the resulting contraction afterward drawing everything firmly together as the rivet gets cold, and strengthening the joint by the well-known effect of the friction between its parts.

Again, there are very many places in the framework of a ship where there is not sufficient space for swinging a hand hammer in driving a rivet, or where the rivet can be gotten at from only one side. Such rivets as those through beam knees and frames, in the connections of floors to center keelsons, wash plates between floors, frame brackets at tank tops and decks, in cellular tanks, and generally wherever the available space is only that of the frame spacing, or less, or where a rivet comes in the bosom of an angle or channel, are of this type, and are among those most important to be well driven, the integrity of the framework depending largely upon them. From the nature of the case, hand-driven rivets in such situations are not what they should be, but it is evident that such considerations do not affect the machine in the slightest degree, and that if the hammer can get on to the rivet at all it will drive it as well in such locations as in the most open parts of the work.

Passing now to the case of a rivet so located in the ship that it is not possible to get at both sides of it by a bow frame, we must distinguish at once between those that are finished with a full or button-head point, as in bulkheads, and those with a counter-sunk flush point, as in decks, tank tops, and the outside shell. For decks and tank tops, where the rivets are put up from below and the action of the hammer is always vertically downward, a simple arrangement of the hammer mounted on a bent pipe as if on a wheelbarrow with one or two wheels is all that is necessary. The operator raises the handle end sufficiently to get the die over the point of the rivet and then bears down as the air is turned on, the bend of the pipe being loaded with lead. A second man with a chipping hammer cuts off the surplus metal, and a few seconds' work of the riveter again suffices to complete a very satisfactory



WORK PERFORMED BY PORTABLE PNEUMATIC RIVETERS AT SOUTH CHICAGO SHIPYARD.

operation. A pneumatic holder-on is used below, and three men and a heater boy will drive from 800 to 1,000 rivets in a day.

In the case of bulkhead rivets, it is evident that the combined hammer and holder-on can be fastened to the end of a beam which slides loosely on a central supporting stud bolted to the bulkhead, with an adjustable stud bolt on the other end of the beam governing the distance of the hammer die from the rivet point, and reaching a good many rivets at one setting. The pneumatic holder-on may be similarly mounted on the other side of the bulkhead.

The die is cupped out, and it is evident that after the first stroke of the hammer the die will be firmly held in position by the metal, which is forced into the hollow of the die. The holder-on is similarly kept central with the rivet by its hollow-ended die going over the head. The resulting finished rivet is all that can be desired.

In the case of flush-pointed rivets, however, a very different arrangement is required. It is evident that, as in handwork, the varying thicknesses of plating, liners, butt straps, frame flanges, etc., and amount of countersink in the plate, make it impossible to so gauge the length of the rivet under the head that, when beaten down, it will exactly fill the countersink and finish flush with the surface of the plate. The only practicable method of driving is to follow as closely as possible the hand method, beating the rivet down with the surplus metal crowded off to one side, chipping this surplus metal off by a cold chisel, either by hand or by an ordinary pneumatic chipping hammer, and then properly finishing the point.

To do this it is necessary that some freedom of movement be given to the hammer—that is, it must be possible to incline the axis of the hammer to a slight angle with the axis of the rivet in any direction, in order that the surplus metal in the point may be properly crowded off to one side to make easy chipping, and also that the point may be properly finished, and, if necessary, slightly rounded, and any seams around the point between the rivet and the plate properly driven together and made watertight.

Three methods may be used for fastening the hammer to the beam: First, the hammer may be mounted in gimbals; second, the hammer may be so mounted in a frame that while the die is held in position against the rivet, the lower end may be given a rotary movement; this is not as good as the gimbals; third, the hammer may be mounted on trunnions, and the beam carrying it turned on its own axis and moved forward and back longitudinally. The third method does not seem very practicable, and we have never tried it.

There is still another method by which countersunk flush rivets may be driven by hammers. In this, the hammer is fastened immovably to the end of the beam, as in the bulkhead riveter, and the flat-faced die has a central hole about 3-16 in. dia. drilled in it. When the rivet is beaten down some of the hot metal enters the hole and the result is a projecting teat on the rivet point, the remainder of the surplus metal flattening out equally on all sides.

This surplus metal is removed by a face milling tool, also made with a central hole, which fits over the teat and holds the tool in position. The milling tool is driven by a pneumatic drill, and after the point of the rivet is milled down flush with the plate the teat is easily cut off by a blow of a hand hammer on a cold chisel. The rivet, however, is not finished in quite as "ship-shape" a manner as by the other method, and we have had so much difficulty in getting a milling tool of the right shape to cut properly that we have abandoned it.

In the Chicago yard, therefore, the only method now used is the first one cited above, which has proved most satisfactory in every way, both on new construction and in the dry dock on repair work. The construction and mounting of the hammer in the gimbals on the end of the pipe beam gives it the necessary swinging motion, as well as a certain amount of motion bodily sideways in any direction without moving the beam. For bottom rivets the beam is hung by a bolt through its center, on which it rotates, to a trolley running inside of a slotted pipe which is bolted to the bottom of the ship, enabling the operator to reach many rivets at one setting. In a variation of the same arrangement, instead of bolting the slotted pipe to the ship, it is held firmly up against the bottom by the simple pneumatic jacks at each end. This avoids missing any bolt holes and is well suited to work in the dry dock.

For the side of the ship the mounting we have so far found most satisfactory is provided with a short vertical beam carrying the hammer and provided at its lower end with an adjustable bolt to govern the distance of the hammer from the rivet. This beam is fastened to a bored-out tee which slides freely on the horizontal pipe. This pipe is counterweighted and hung from pulleys above inside of flat iron guides bolted to the ship's side. The resulting free vertical and horizontal movement of the hammer enables a large portion of the side to be covered without shifting the rig.

For the bilges, which for a large portion of the length of our lake ships are circular, the hammer beam is again a horizontal pipe fastened to a double frame which fits the bilge and travels fore and aft on trolleys above and below.

It will be understood that for all these shell rivets the method is to beat down the head to fill the countersink, chip off the surplus metal, as in hand riveting, by a chipping hammer, and then finish by the machine. In all these methods of mounting, after the rivet is plugged and the head is beaten down, the hammer is easily swung out of the way to enable the chipping to be done.

In all cases the pneumatic holder-on is used against the head of the rivet inside. For the bottom and bilges, the tank top lends itself with facility as a support against which the holder-on can be braced by means of the pipe extension referred to above. In a single ship bottom little difficulty is experienced in adjusting a short piece of plank as a brace by means of hook bolts taking hold of the reverse bars. For the side rivets we have found a simple method to be the use of two pieces of 6 in. by 6 in. scantling extending from the tank to the deck above or from deck to deck, easily bolted in position about 8 ft. apart, with a horizontal piece of 2 in. plank sliding freely on their outboard sides. The plank forms the brace for the holder-on, and is counterweighted and easily moved up and down in unison with the horizontal pipe carrying the hammer outside.

As for the quality of the work done by these various methods of power riveting, I can say that the unanimous opinion of the hull inspectors who have been on duty in our yard for two years and more is that the rivets are first class in every respect, and make far better and tighter work than those driven by hand.

As for the cost, I will say that, adding cost of air, repairs, etc., the saving is from 1 to 2 cents per rivet over piece-work prices for hand riveting, depending upon the location in the ship and averaging about 1 1-4 cents. In an ordinary lake steamer of 4,000 tons the saving is from four to five thousand dollars over hand work.

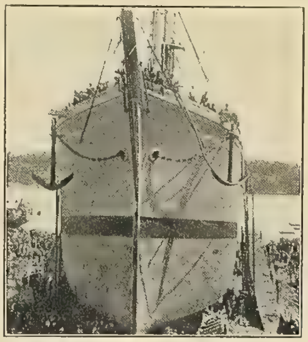
A further and very important advantage, however, is in the fact that skilled labor in one of the principal departments in a shipyard, which has hitherto been indispensable and correspondingly arrogant and high handed, can be replaced by unskilled labor.

In conclusion, I want to say that the quality of the work done by portable pneumatic riveters in ship building is such that the various classification societies cannot ignore it, and before very long will doubtless recommend, if not require, that all rivets in at least the principal portions of the ship be driven by power.

A trial trip of the S.S. La Grande Duchesse recently made to determine the efficiency of her new cylindrical boilers gave very satisfactory results. The coal consumption per I. H. P. per hour averaged about 1.535 lb., which included all coal used for the main engines and auxiliaries, the indicated horse power being that of the main engines only. This ship is now fitted with four main boilers and one donkey boiler, all of the Scotch type. All the boilers are constructed for a working steam pressure of 210 lb. per square inch. The main boilers consist of two double-ended boilers, 15 ft. 3 in. mean dia. by 20 ft. 0 in. long, and two single-ended boilers 15 ft. 3 in. mean dia. by 10 ft. 3 in. long. Each front is fitted with four Fox corrugated furnaces 38 3-4 in. inside dia., each furnace being fitted with a separate combustion chamber. There is a total of 17,100 sq. ft. of heating surface in the main boilers and 410 sq. ft. of grate area, the grates being 5 ft. 3 in. long. The main boilers are fitted with the Ellis & Eaves system of induced draft, with vertical 2 3-4 in. dia. heater tubes in the uptakes in front of the boilers. The products of combustion pass through the tubes, and the air is drawn in around the tubes, and after being heated, conducted to the ash pits through ducts running down the front of the boilers, at the sides and between the uptakes. The induced draft is furnished by an installation of three Sturtevant steel plate steam fans, placed under the stack, each having a wheel 8 ft. dia., and fitted to draw from the uptakes and discharge into the stack. The La Grande Duchesse is a twin-screw vessel of 5,000 gross tons. She was built by the Newport News Shipbuilding and Dry Dock Co., which also furnished the new boilers.

STEEL VS. WOOD AS A MATERIAL FOR SAILING SHIPS, WITH DATA OF AMERICAN SHIPS IN SERVICE.

BY WILLIAM A. FAIRBURN.



SHIPENTINE ROANOKE.

About a quarter of a century ago the wooden sailing vessel ceased to be a carrier of any significance in the British trade, but it was not until five years ago that wood was finally abandoned in favor of steel as a material for the construction of sailing ships in our own country. There are, however, only four American iron or steel sailing ships afloat to-day, and only two of them are of American construction. Their particulars follow:

The American four masted ship or shipentine Kenilworth was originally a British vessel, having been built by J. Reid & Co., of Port Glasgow, Scotland, in 1887. A few years ago she was badly damaged by fire in San Francisco. The insurance companies paid a total loss on her and then sold her to Arthur Sewall & Co., of Bath, Me., at a very low figure. After being rebuilt she was granted an American register. Quite recently she put into Valparaiso with a fire in her hold, and her master, Capt. J. G. Baker, the mate and cabin boy suffocated by the fumes and gases from the burning cargo of sugar. The Kenilworth has been an unfortunate vessel. She was well designed and well built, but she cannot be called successful. She is 300 ft. long, 43 ft. beam and 24 ft. deep. The gross tonnage is 2,293 tons and the net 2,179 tons. The main mast truck is 155 ft. above the deck, and the lower yards are 88 ft. long. The masts and bowsprit and the three lower yards on each mast are all of steel, while the smaller spars are of wood. She carries a crew of 35 men.

The four masted ship May Flint is the largest of the American sailing ships. She was formerly the transatlantic passenger and freight steamship Persian Monarch, having been rebuilt at Newport News in 1895. This vessel is 350 ft. long between perpendiculars, 370 ft. over all, 42 ft. 6 in. beam and 36 ft. 3 in. deep to upper or hurricane deck. These proportions are unsuitable for a sailing vessel, and therefore she greatly lacks initial stability. The May Flint is of the usual iron steamship construction, with a cellular double bottom 39 in. deep. Her lower yards are 93 ft. long; the royals are 56 ft. long; the mast from deck to truck measures 159 ft., and she spreads 44,000 sq. ft. of sail. On her maiden voyage she carried 4,320 tons of coal from Baltimore to San Francisco, on a draught of 23 ft. 1 1-2 in. The May Flint has a very small dead weight capacity for so large a vessel, for when light she weighs 2,750 tons. Under certain conditions of lading she would be an unsafe vessel.

The other two American steel ships were built at Bath, Me., at the yard of their owners, Arthur Sewall

NEW STEEL SHIP ERSKINE M. PHELPS—4,500 TONS D. W.

WOODEN SHIP ROANOKE OF BATH, ME.—3,539.03 TONS.

WOODEN SHIP SUSQUEHANNA OF BATH, ME.—2,744.67 TONS.

& Co. They are of the same general dimensions although they differ in model and in various details. The Dirigo is named after the motto of the State of Maine—"I lead"—and she was the first steel sailing ship to be built in America. This vessel was launched February 10, 1894. She is 312 ft. long, 45 ft. beam and 25 ft. 6 in. deep. Her gross tonnage is 3,005 tons and her net tonnage 2,886 tons. The Erskine M. Phelps was completed a few months ago. She is a modified Dirigo, and whereas the latter vessel was built of British steel the Phelps has been constructed throughout with material of domestic manufacture. She is a little finer aft than the Dirigo and is in many respects a much superior vessel to her predecessor.

The Phelps carries 4,500 tons dead weight on 22 ft. 6 in. draught and she stands up without ballast when light in port. This vessel has great stability at light draughts and she is also a stiff boat when loaded with any homogeneous cargo. She has a dead rise of 20 in. with a very easy rounding bilge. She is a moderately fine ship, the coefficient of displacement excluding the keel, being .72. The vessel has a flush main deck of steel fore and aft, the whole of which is sheathed with 3 1-2 in. hard pine planking. The lower deck has steel stringers and tie plates, and it is planked with 3 in. hard pine. A lofty topgallant forecastle with lamp room and store rooms at the sides is fitted forward. There are two steel commodious deck houses, the forward and larger one of which contains comfortable quarters for the crew, also the galley. The smaller deck house aft is fitted up for the accommodation of all the apprentices and petty officers; it also contains the carpenter's shop. There is a large full poop aft, in which is the captain's accommodation, and a nicely furnished saloon 16 ft. square on the starboard side. The mess room and pantry is in the center, while the officers' cabin and two spare staterooms are fitted on the port side, the sail room occupying the space in the lazarette. On top of the poop is a steel chart house which also forms a cabin entrance. The vessel is steered by screw steering gear, the helmsman being protected by a steel hood open on the forward end. A large fore and aft flying bridge is fitted connecting the poop and topgallant forecastle, a great convenience in bad weather. The scantlings of the vessel are equal to Lloyd's highest class, and she has received the highest rating from the American Bureau of Shipping. The Lloyd's numerals are: Transverse No. 96.75; longitudinal No. 29828. Proportions length to breadth, 6.85; length to depth, 10.92. The Phelps has a well proportioned sail plan. The lower masts and topmasts are in one length, measuring 134 ft. The spike bowsprit 67 ft. long; the lower yards 92 ft. long; and the upper and lower topsail yards are all of steel. She carries single topgallant sails, also a royal and a skysail. She has therefore six yards on each of the fore, main and mizzen masts, and being rigged as a shipentine, she carries no yards on the jigger mast. The vessel has four head sails, three main, three mizzen and four jigger stay sails, and with the spanker and spanker topsail she carries thirty-four sails all told, spreading about 12,500 yards of canvas. A donkey engine of 20 horse power works the ship's windlass by means of a messenger chain, and the same motive power is used in port for discharging and taking on cargo. Her three bower anchors collectively weigh 13,400 lb., excluding stock; the two largest ones weigh 4,700 lb. each. She also carries a stream anchor weighing 1,500 lb., and two kedges, one of 750 lb. weight, and the other 400 lb. The equipment of this fine vessel also includes 240 fathom of 2 1-8 in. stud link chain cable, 120 fathom of 4 1-4 in. steel wire and 90 fathom of 4 1-2 in. flexible steel wire tow line, besides the usual hawsers and warps. The crew consists of twenty-four men before the mast, two boatswains, three mates, cook, steward, carpenter, engineer and four boys, thus making a complement of thirty-eight hands all told, including the captain.

Arthur Sewall & Co. are now building their third steel ship, which is the forty-second vessel which has been built by this firm. This ship is now framed and one-half plated, and her construction is therefore well advanced. She will probably be named the Arthur Sewall. This vessel is much larger than the Dirigo and the Erskine M. Phelps, but her model is very similar to that of the latter vessel. The owners are the only builders of sailing ships in the country to-day. They abandoned wood construction after launching the Roanoke in 1892, and they now own a fairly good and well equipped steel shipbuilding plant in Bath, situated on the west bank of the Kennebec, a river that has probably christened more sailing tonnage than any other river in the world.

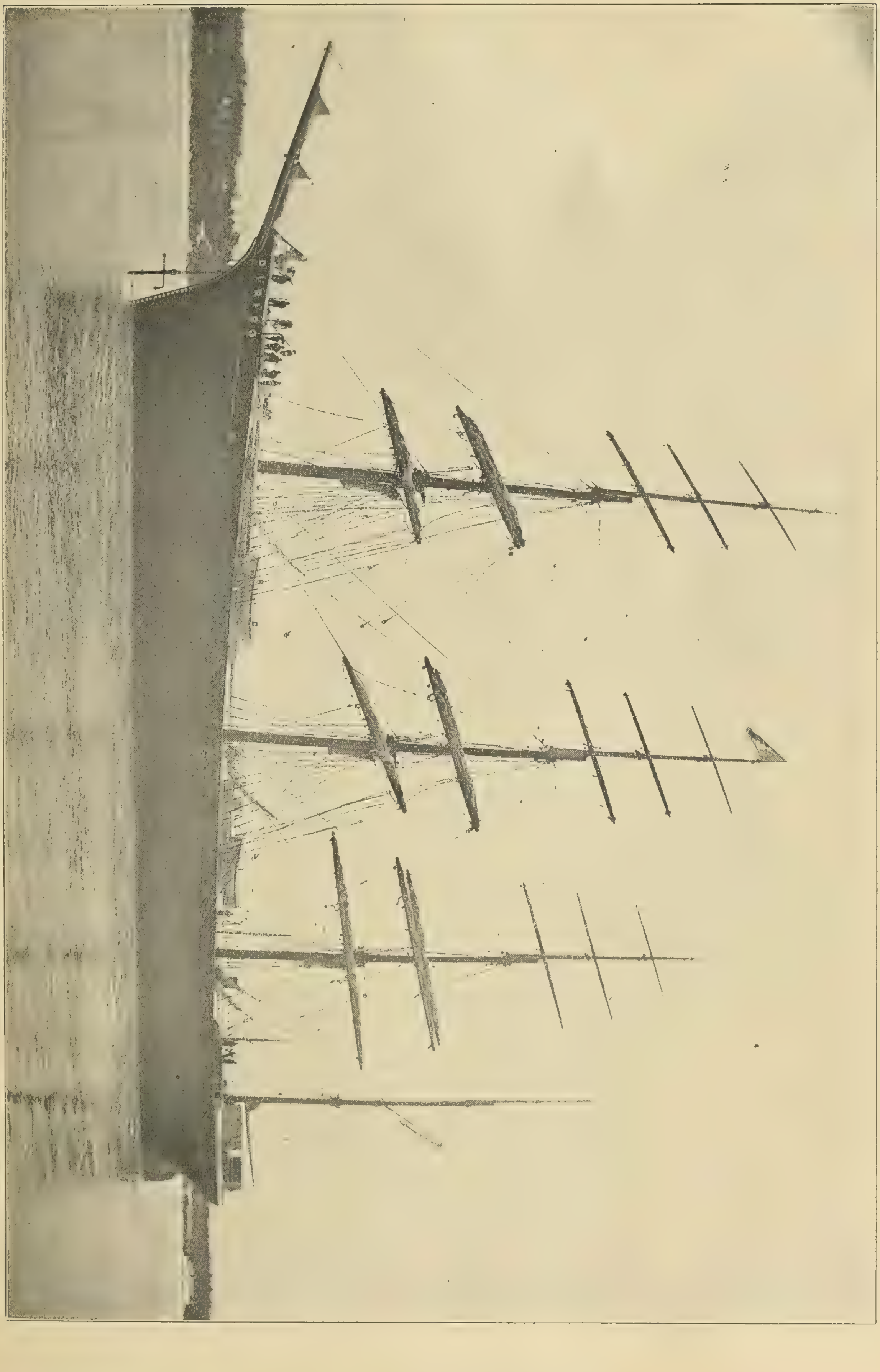
The Roanoke was the last of Sewall's wooden ships, and she is known as the last of the "Big Four," and also as the largest wooden sailing vessel afloat. During the three years preceding the installation of their steel plant A. Sewall & Co. constructed four massive wooden ships, well known as the Rappahannock (burned at sea 1892), Susquehanna, Shenandoah and Roanoke. The last three ships have proved very good vessels, although they cannot successfully compete with modern steel tonnage. The following are their principal dimensions:

	Gross Tonnage.	Net Tonnage.	Length.	Breadth.	Depth.
Roanoke.........	3,539	3,400	311.2	49.2	20.2
Shenandoah.....	3,407	3,258	299.7	49.1	19.9
Susquehanna....	2,745	2,629	273.6	45.1	19.1

The foregoing figures are custom house measurements.

We hear at times even to-day considerable controversy concerning the relative merits of wooden and steel ships. The following figures do not require any explanatory notes, as they state facts which prove the great superiority of steel over wood as a shipbuilding material.

The Shenandoah and the Erskine M. Phelps are two ships both of which have been built to fulfil the same requirements. The Shenandoah is looked upon as the finest and most successful wooden sailing vessel afloat, while the Phelps can be regarded as a fair sample of heavy modern steel ship construction.



SHIP DIRIGO, BUILT AND OWNED BY ARTHUR SEWALL & CO., BATH, ME.—FIRST STEEL SAILING SHIP BUILT IN AMERICA—G. T. 3,004 TONS.

The Phelps carries a little more deadweight than the Shenandoah, and the weight of her complete hull and fittings is less than 73 per cent of that of the wooden vessel. The Shenandoah's initial cost was a trifle less than that of the Dirigo, but the actual cost of the Roanoke and Dirigo was probably about the same amount, viz., $150,000. A sixty-fourth of the Roanoke was sold for $2,800, and the same amount of the Dirigo was sold for about $3,000 (a high figure), or 7 per cent more, the capacity of these two vessels being about the same. The Phelps has been constructed for a much less figure than the Dirigo, the actual cost of this vessel being quite as low as that of any wooden ship of her size.

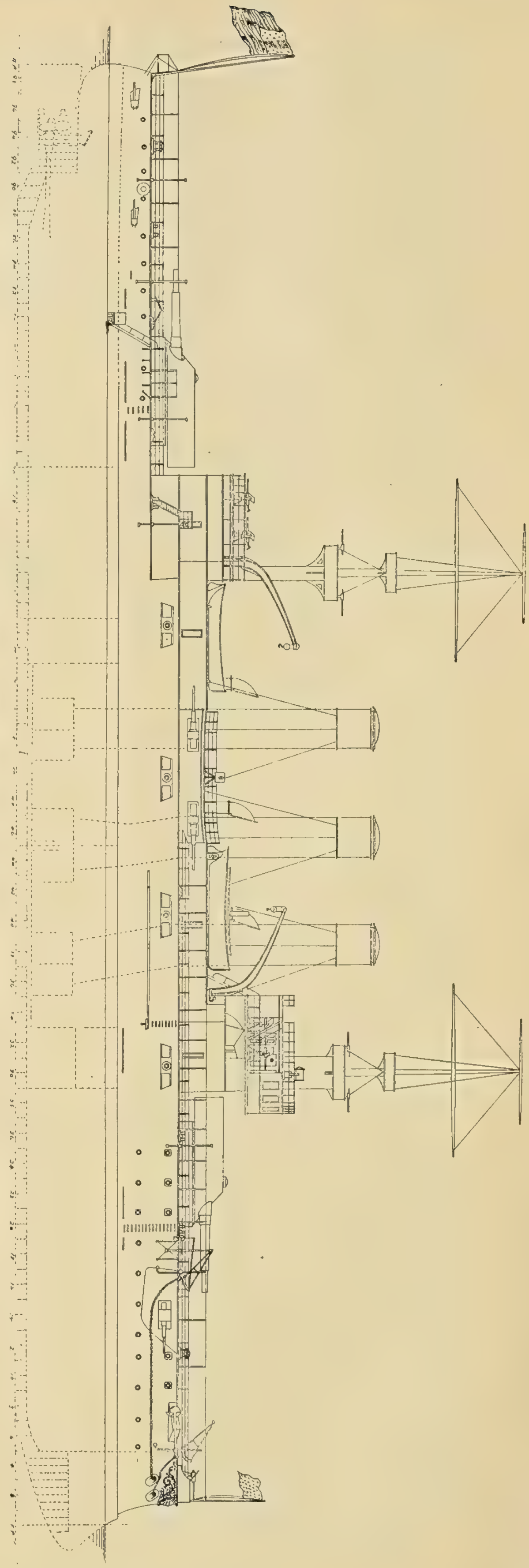
	Shenandoah.	Phelps.
Launching draft (similar conditions)	10 ft. 9½ in.	7 ft. 1½ in.
Weight of finished hull, % of displacement	35.5	28.5
Deadweight carried per ton reg	1.37	1.56
Deadweight carried per ton weight of finished hull	1.81	2.5

The building price of a large wooden ship to-day is about $45 to $50 per ton, and a modern steel ship can be built for about $50 to $55 per ton with a fair profit.

Steel ships not only have a great advantage over wooden vessels in deadweights carried, but they are stronger and stauncher, they last longer, and have a much greater hold capacity on the same outside dimensions.

U. S. Ss. Maine, Missouri and Ohio.

Some time ago we published the general characteristics of the new battleships Maine, Missouri and Ohio, for which contracts were made in October last. In the accompanying drawing a correct profile of these fine vessels is given. Though in general following the lines of the earlier and well known battleships the new vessels will have several readily apparent differences. They are high forward and low aft, and have three smoke pipes ranged in a fore and aft direction. Each turret will contain two high-power 12 in. guns, which, using smokeless powder, will have a muzzle velocity of 3,000 ft. per second. They will also each carry sixteen 6 in. rapid-fire guns and a large number of 6-pounder, 1-pounder and machine guns. One improvement to which Chief Constructor Philip Hichborn, U. S. N., attaches much importance will be the installation of under-water torpedo tubes. Each ship will have two submerged tubes in a single compartment fitted up for the storage of eight 17 ft. torpedoes, and appliances for handling and operating them. Taking the Maine as representative of the type, some of the dimensions and particulars are of special interest: Length, L. W. L., 388 ft.; beam, moulded, 72 ft.; freeboard, forward, 20 ft., aft, 13 ft. 3 in.; mean draught, with 1,000 tons of coal and all stores and ammunition, 23 ft. 10 in.; corresponding displacement, 12,500 tons; speed, 18 knots; and I. H. P., with assisted draft, 16,000.



PROFILE OF THE NEW FIRST-CLASS BATTLESHIPS MAINE, MISSOURI AND OHIO, 12,500 TONS—RECENTLY CONTRACTED FOR.

CONSIDERATION OF THE INDICATOR AND ITS USES ON BOARD SHIP—I.*

BY R. W. JACK.

It is a somewhat difficult task to appreciate the true importance of the application of this device, to the scientific study of the behavior of steam subject to such diverse and varying conditions as we find ruling in its transmission of work. If, however, we approach the subject of steam engine efficiency from its inception with a diligent regard for its history and progress, we can scarcely escape the most certain conviction of the genius of Watt, in the highest sense to which that attribute has been applied.

We are apt to look lightly upon anything with which engineers have been familiar for a hundred years, but if ever a doubt should arise in our minds in regard to Watt's scientific attainments, nothing further need ever be remembered than that it is to him we owe this valuable invention. The development of the steam engine has been as truly a scientific achievement as that to which the progress of any other branch of art has been due. Looking backward, it is really wonderful to find how complete were the theories advanced by this pioneer in the application of steam to mechanics, and how fully their truth has been borne out in modern practice. The steam engine indicator in its primitive form was simply an instrument meant to record the pressure of steam in the cylinder, without regard to the position of the piston. This function alone was then necessary, since at that period the steam was carried the whole length of the stroke, but we are nevertheless indebted to Watt for the diagram of work as represented by an ordinary indicator card, and which he used to prove the economy of working steam expansively. The improvements which have taken place since its first application to a steam cylinder have been merely mechanical.

It is now recognized that the requisite qualifications of a good indicator are, first, a strong spring so adjusted to the extreme limits of pressure to which it is applied, that its greatest compression or tension shall not materially disturb its axis or unduly bend the spring; second, that the moving parts shall be as light and frictionless as is consistent with its work. The most important modifications and improvements have been effected by McNaught, and by Richards, whose apparatus remained for many years the standard, while of late years many beautiful adaptations of the parallel motion and perfected mechanism have combined to render the instrument extremely sensitive, and in careful hands the diagram taken may be considered as nearly approaching accuracy as it is possi ble such a device can ever attain to. It may be conceded that to offer instructions as to how the necessary precautions and adjustments ought to be made lies rather outside the scope of this essay, and that upon a subject with which we are all more or less familiar, the necessity mainly rests not so much on the practical application of the indicator, as upon the principles which underlie a correct appreciation of its details.

* From a paper read before the Institution of Engineers and Shipbuilders at Hong Kong.

It will be obvious to all that to obtain the correct diagram an indicator should be placed as closely to the cylinder as is possible with convenience in manipulating it. The position and lead of the orifice which connects with the end of the cylinder s ould be selected so as to prevent any undue influence of the entering or exhausting steam, for it is well known that a jet of steam in blowing across the mouth of an orifice tends to reduce the pressure in its connections. If pipes be used, as they almost invariably are, for convenience in obtaining with a single indicator diagrams from both ends in quick succession, they must be of ample size and well protected by non-conducting material. The motion communicated to the paper cylinder should exactly correspond with the motion of the piston of the engine. In practice this is rarely the case, but the error is generally so small that it approaches sufficiently for most purposes to perfect synchronism. If the motion be taken from the crosshead of the engine, the length of the lever from which the paper barrel receives its partial rotation should be as great as conditions will conveniently permit. It may also be pointed out that in every case the cord or wire should be led at right angles to the lever, when the piston is in mid-position, otherwise the error is aggravated at one end of the stroke and diminished at the other. Those propositions may be easily verified by the aid of a pair of compasses.

Take the first case as represented by Fig. 1. Let $A\ B$ be the stroke of the piston, and $a\ b$ the

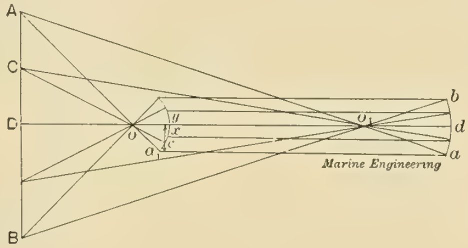


FIG. 1

reduced motion to be communicated to the paper drum of the indicator. Divide $A\ B$ and $a\ b$ into equidistant spaces, say we take 4, then by shifting the position of the fulcrum o outward, thereby increasing the length of the lever, it will easily be seen that the error gradually decreases. For instance, take the first fulcrum o, the length of the lever is $D\ o$. From A draw Aa_1, then oa_1 will represent the short arm of the lever. When the crosshead (or piston) is in the position indicated by C, i. e., one half the distance $A\ D$, the position on the indicator diagram would be represented by c, instead of which it should have been at x, which is one-half the distance "$a\ d$." Referring to Fig. 1 it will be seen that, in the extreme case we have taken with the fulcrum at o, toward the ends of the stroke, the motion is almost imperceptible, although at mid-position $D\ o$ both points are moving with the same velocity, consequently unequal relative spaces are passed over in the same time, thereby making the indicator diagram highly erroneous and rendering it completely useless for its intended purpose. If the crosshead moves from A to C, the distance shown by the diagram will be the vertical distance between a_1 and c, while for the same distance traveled by the crosshead, $C\ D$, the length on the diagram will be represented by the vertical distance between c and y. I think it will thus be evident to most engineers that a theoretical curve superimposed upon any diagram which may have been taken regardless of the synchronizing of the paper cylinder with the piston of the engine is necessarily misleading. Again, if we look at Fig. 2, it will be seen that at one end of the stroke the lever and cord are almost in line, and the

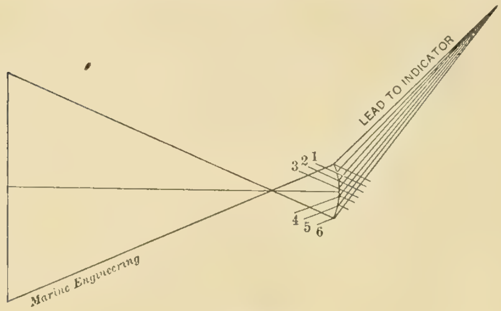


FIG. 2

consequent motion is therefore comparatively slow, while at the opposite end it is at a maximum. Fairly accurate results will be produced with a lever whose length is about 1 1-2 times the stroke of the engine, and if it be worked by a swinging link from the crosshead, the length of such link should not be less than one-third of the stroke. With those proportions the adjustments may be made as in Fig. 3. In any case the connections should be as direct and rigid as the

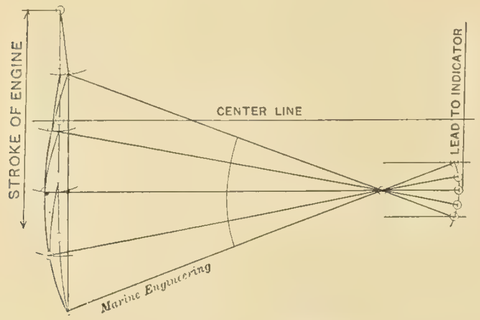


FIG. 3

circumstances will allow, and to this end brass wire may witn advantage be substituted for the cord generally used.

An engineer will scarcely require to be told that his best attention is absolutely necessary to every detail connected with the working of the indicator if he would obtain a true diagram and learn what it can teach. Before applying the pencil to the indicator for the purpose of taking a reading the instrument should be tested with the lightest spring of the set. After the various parts have been thoroughly cleaned and oiled, they should be carefully put together, the bracket sleeve carrying the parallel motion is turned until it bears against the stop, and the pencil is adjusted until it just lightly touches the paper drum. Place the paper in position by first folding one edge backward, wrap it tightly around the drum and fold the other edge of the paper back between the clasps. First describe a line on the paper by slightly rotating the paper cylinder by hand; press the piston of the indicator down, and release it very gradually; trace another line; compress the spring by drawing the piston outward, release it slowly and trace again. Those three lines should exactly coincide. It is a test of the whole motion being perfectly free from friction and in good working order. The cord or wire should then be so adjusted that a margin is left at the extremities of the travel to prevent tne paper drum from touching the stop at either end. The total length of the diagram is generally about 5 in., and it is supposed that the motion is reduced to give the exact travel. The indicator should be allowed to work for a few seconds before taking off a diagram, in order that it may attain the proper temperature and approximate more closely to the working conditions. It is also advisable that the pipes themselves should be blown through before attaching it.

Diagrams may now be taken from either end in succession and the atmospheric line traced before the paper is withdrawn. We must now trust to our experience and the knowledge we possess to locate any faults, whether they exist in the instrument itself or are attributable to defective adjustment of the machinery. To enable us to read a diagram and to understand and account for the complete figure, it is necessary that we should be familiar with at least the simplest form of valve gear. For this purpose it may be well to state the conditions under which it is most desirable to work a reciprocating engine. Let the piston be supposed at one extremity of the cylinder and under working conditions; steam is admitted and follows the piston at full pressure for a certain part of the stroke. The cylinder is then closed to its source of supply and the enclosed steam expands with diminishing pressure until toward the end of the stroke the cylinder communicates with the exhaust chamber, and this side of the piston remains in this state nearly the whole of the return stroke. At a certain distance from the point whence the piston began, the cylinder is closed to exhaust and the imprisoned steam is compressed by the advancing piston, while still nearer to the extremity of its travel, the cylinder again connects with the source of energy. Those are the points which may be said to be essential to the economical working of the engine, and an indicator diagram will show more or less distinctly each succeeding change and period. Whether it be possible to attain the perfect distribution of steam will primarily depend upon the skill of the designer, and to some extent upon the attention bestowed on the machinery by those in charge. An indicator diagram taken with all necessary precautions must be the final arbiter of the claims of the various valve gears, and so far the oldest and simplest of the surviving valve motions still holds the field. The link motion, as it is called, driven by eccentric pulleys placed on the main shaft, is still the commonest form of device used for communicating the requisite movements to a slide or piston valve, so that unless otherwise specified it will be understood that it is to it I may apply my remarks.

We are now in possession of the elementary principles which regulate the reciprocating action of a steam engine, and we are prepared to expect an approximate figure to that which theory would suggest. The principal objects of an indicator diagram are, first, that we may be enabled to calculate the power exerted by the engine, from the mean effective pressure shown by the diagram; and second, that we may observe the behavior of the steam upon either side of the piston during each interval of time required to complete one revolution of the engine.

The diagram shown in Fig. 4 will serve to illustrate the method of finding the mean pressure. The length

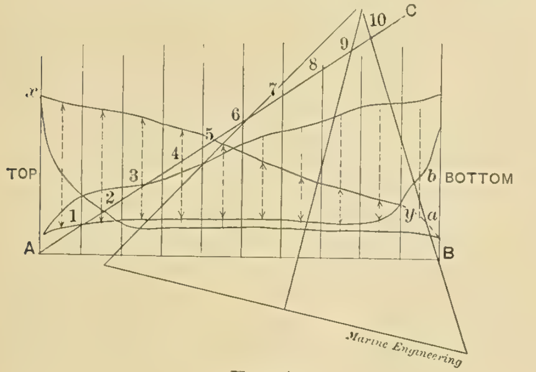


Fig. 4

of the diagrams between perpendiculars raised from the base or line of atmospheric pressure, and touching the extremities of the figures, is first divided into a number of equal spaces. Any number of spaces may be taken, and it will to some extent depend upon the uniformity of the diagram. The greater the number of divisions, the more accurate will be the result. It is generally sufficient in practice and most convenient for calculations to adopt ten. If the figure is very irregular in any division, that particular space may be further subdivided, and the mean taken to represent that space, but such refinements are seldom necessary. Each division is measured midway between the perpendiculars with a scale corresponding to the spring used, the whole added together and divided by ten is the average pressure acting on the side of the piston. The opposite side is treated in the same way and added to the former. This result, divided by two, represents the mean effective pressure on the piston during a complete revolution of the crank. If, however, a set of cards have to be measured by hand it is better to mark off on a strip of paper each consecutive distance, beginning from the one extremity and following on, so that the total length of all the distances is the sum of the pressure by scale. This again divided by ten gives the mean pressure. The usual plan of measuring each diagram separately, though it may approximate the true value, is nevertheless wrong, because pressure alone is not a measure of work. What we really wish to ascertain is the difference of pressures at those intervals existing between the two sides of the piston, so that a diagram from one side should be measured not alone, but with regard to that taken from the other side at the same instant. We should therefore measure from the steam side of the diagram, which we are considering, to the back pressure or exhaust side of the opposite diagram. This will give us the true effective pressure and guide us in a more correct estimate of the varying stresses on the crank pin. In Fig. 4 is shown this method of measurement. The distances between the arrow heads are the true effective pressures, acting either in one direction or the other. On the side marked *Top*, for instance, the effective pressures are all positive from x to y, i. e., the pressure of steam on the top side of the piston exceeds that on the under side at the same instant, until the piston attains the position indicated by y. At this point the pressures balance each other, and the remainder of the stroke is actually performed against a greater pressure acting on the under side, so that we must subtract the distance a b, or negative pressure, from the aggregate positive pressures.

In the indicator diagram (Fig. 4) is also shown an accurate method of dividing the length of the card A B into ten equal divisions. Draw a line at any angle in the direction A C. With a pair of compasses set to any approximate distance, mark off on the line A C ten equal divisions. Join 10 and B, the other extremity of the diagram, and with a pair of triangles divide the line A B into the required divisions by shifting the triangles about to suit. If the length of the diagram be fixed in each case, occasion should never arise more than once to subdivide it by geometry, for the correct diagram may be kept for future reference. In most cases the indicator will admit of a diagram being taken 5 in. long, and the gear once set should never be altered, or means taken to ensure the exact position of the pin on the lever, whence the paper drum receive its motion. This length lends itself to an easy division of half inches. In order to facilitate the working out of the mean pressures, a simple and convenient device has long been in use, and is sold either with the indicator or supplied singly. It consists of eleven parallel bars of thin steel, of equal lengths, placed at equal intervals and all connected at the extremities by two parallel frames. An instrument called a planimeter is sometimes used where the taking of diagrams is a frequent occurrence, or for office work. Being a mechanical contrivance it is more accurate and quicker than the geometrical method. The area of the figure as shown by the planimeter is divided by the total length of the diagram, and this, as before, gives us the mean pressure according to scale. From what has been said regarding the correct method of estimating the mean pressure, it will be obvious that two operations by the planimeter become necessary. Fig. 5, first, to ascertain the area of the larger figure a, b, c, d, e, f; and second, to find the area of the smaller figure c, g, h. The latter should then be subtracted from the former and the difference divided by the total length of the diagram as before. This again multiplied by the scale corresponding to the spring in use gives the mean pressure acting on the top side of the piston. The mean pressure acting on the under side of the piston is found in the same manner, added to the former and divided by two. The quotient should be the exact effective mean pressure on the piston during a complete revolution of the crank.

Having obtained the mean pressure by any one of those methods, we may with the information thus supplied by the indicator calculate the power exerted by the engine. Work may be defined as the product of pressure and space, and power as the product of work and time. The British unit of work is a weight of 1 lb. raised vertically through a space of 1 ft., and the unit of power, as decided by Watt, and called a

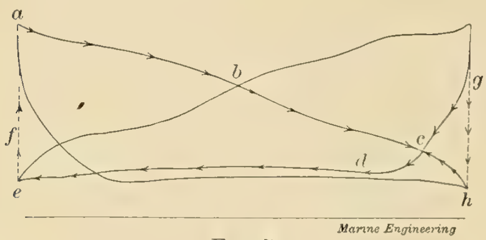


FIG. 5

horse power, is 33,000 foot-pounds exerted for a minute. To calculate the power of an engine we must therefore be provided with certain measurements. We know the mean effective pressure per square inch of piston surface, and to find the total effective pressure we must ascertain the total number of square inches or the area of the piston. The area of a piston is equal to $d^2 \times .7854$ or $(\frac{d}{2})^2 \times 3.1416$. The latter way is the quicker if worked by common fractions, for 3.1416 is approximately 3 1-7. Find the space through which this force acts during one minute by multiplying the length of the stroke in feet by 2 and by the number of revolutions per minute. This is the total travel of the piston in the given time.

The indicated horse power is therefore $= (d^2 \times .7854 \times l \times 2 \times r \times p) \div 33{,}000$ where—

d = diameter of cylinder in inches; l = length of stroke in feet; r = revolutions per minute; p = mean pressure as found from diagram in pounds per square inch.

To save time in calculating the power from a number of diagrams, taken under different conditions, constants may be obtained by working out all the known quantities and thereafter completing the operations with the numbers which are variable. For instance, in the equation I. H. P. $= (d^2 \times .7854 \times l \times 2 \times r \times p) \div 33{,}000$, the quantity $(d^2 \times .7854 \times 2 \times l) \div 33{,}000$ never changes, so that if this be already worked out, it only remains to be multiplied by the mean pressure (p) found from the indicator diagram and by the revolutions (r) per minute. The equation therefore becomes, I. H. P. $= c \times p \times r$ where c is the constant so obtained. Or by having the formula worked out for a range of revolutions between which it is usual to work the engines we may obtain constants for every approximate condition of speed. If we know that the engines are running between the limits of, say, 60 to 70 revolutions per minute, constants may be calculated for every half revolution, and when working out the power of an engine between those speeds it will only be necessary to select the one nearest to that which corresponds with the speed of the engine when the diagram was taken. The general expression for the constant c in this case is therefore $(d^2 \times .7854 \times l \times 2 \times r) \div 33{,}000$, and the power is obtained by multiplying the result by the mean pressure, thus, I. H. P. $= c \times p$.

It is common in calculating the power of an engine to neglect the decrease of the effective area of the cylinder caused by the piston rod. In cylinders of large diameter the practice will not, of course, seriously affect the result, but there can be no valid excuse in any case for such a practice. In the case of triple and quadruple expansion engines where the piston rods are all of one diameter, this consideration of the cross section of the rods becomes imperative. The power of an engine will vary exactly as the area of the cylinder when all other conditions are fixed, i. e., if the length of stroke, number of revolutions per minute, and mean pressure are to be certain quantities, then the I. H. P. will be decided by the effective area of the cylinder. It is thus easy to understand that the error will be the more aggravated when the area of the cylinder is small compared with the cross section of the piston rod. For example, take the case of a quadruple expansion engine whose H. P. cylinder is 21 in. dia., and with a piston rod 7 in. dia. The difference in the two methods of calculation is therefore

$$\frac{\textit{area of piston rod}}{\textit{area of cylinder}} \times 100 = \frac{38.5}{346.5} \times 100 = 11.1\%.$$

It may be observed that those calculations are useful only so far as they represent the total work applied to the piston, and give no idea of how it is distributed —in friction internal and external, the working of pumps, valves, etc., and the useful or propulsive effect. To obtain such valuable information, though highly desirable, is rather beyond the scope of this paper, and at the best it might, in the absence of reliable experiment, prove only a very rough guess. But there are other lessons to be learned from the indicator diagram. Although the diagram itself is merely an indication of pressures existing at each interval of the stroke, the essential properties of steam are so fixed and interdependent that we may calculate equally well quantities, densities, or temperatures. It is a highly interesting study to estimate the equivalent weight of steam at certain critical points of the diagram, and thus to observe the alternating nature of the conditions to which it is subjected. Steam in the act of expanding does not follow the simple law of a permanent gas, and its behavior has occupied the attention of the most eminent scientists. What is called "Boyle's Law," or the "Law of Mariotte," has been admitted, and is now established as pertaining only to a perfect gas. Stated simply, it is that the density or pressure of a gas multiplied by its volume never changes, that is to say, suppose we have a cubic foot of gas at a pressure equal to that of one atmosphere, then no matter whether that gas be expanded or compressed, the product of its volume into the pressure which it supports is strictly a constant quantity. If it be compressed to one-half of its original volume, the pressure or density is doubled; if expanded to twice its volume the pressure or density is one-half of the original. Another and shorter way of expressing the same law is to say that the pressure of a permanent gas varies inversely as its volume.

It therefore becomes a simple matter to plot out a curve which shall conform to those conditions. To those who are familiar with geometry the hyperbolic curve at once suggests itself as a perfect solution, and the mathematical location of any point in the curve is so easy that any one who understands the rudiments of arithmetic is able to perform the necessary computations. For instance, consider Fig. 6. Let $A\ B$ represent a certain volume, say the volume of a cylin-

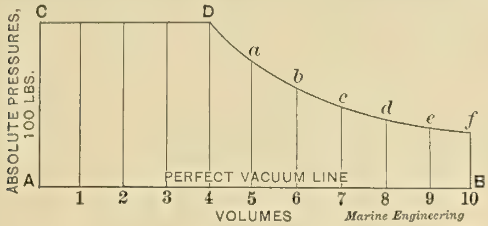


FIG. 6

der in cubic feet (diameter of cylinder in feet squared × .7854 × length of stroke in feet), and $A\ C$ the pressure of steam. Divide the volume $A\ B$ into ten equal divisions, 1, 2, 3, etc. Suppose each division to represent 1 cu. ft. and the pressure of steam $A\ C$ to be 100 lb. per square inch. Let P stand for pressures in pounds per square inch and V for volumes in cubic feet. We will cut off steam say at D, = 4 cu. ft. Now, to find the points on the expansion curve we have only to remember that $P \times V$, or shortly $P\ V$ is a constant, so that to estimate the pressures corresponding to the volumes 5, 6, 7, 8, 9 and 10, we have simply to divide $P\ V$ (i. e., the pressure and volumes before the steam begins to expand) by those numbers representing actual volumes. $P\ V$ is therefore $= 100 \times 4 = 400$. To find the pressures related to the volumes 5, 6, 7, 8, 9, 10, we only require to divide 400 by 5, and by 6, 7, 8, 9, and 10, and mark off the points on perpendiculars raised from the base $A\ B$ to the same scale as that to which the initial pressure $A\ C$ is drawn. Those points we will name a, b, c, d, e, f. A curve drawn through those points is therefore the curve of ideal expansion, otherwise a hyperbola. I have said that saturated steam does not exactly follow this law, but only approximately so. The difference is so little, however, that it is usual to compare the actual diagram with this theoretical figure, and it will be readily understood, when we reflect that before steam may be transformed to water it must part with its latent heat, that under the most favorable conditions the two curves will almost coincide. It will now be seen that if the expansion curve on an indicator diagram were a hyperbola, any number of points would give the same result, because in that case the density or relative weight of the steam varies directly as the pressure and inversely as the volume, so that the equivalent weight of water represented by the steam at any pressure and volume would be constant.

A new 165 ft. yacht for J. H. Ladew, of New York, building at the Crescent Shipyard of Lewis Nixon, at Elizabethport, N. J., is of special interest in that her design is such that she can be readily converted into an auxiliary war vessel. Her hull is modeled on the same lines as those of the Coast Survey steamer Pathfinder, recently launched at this yard.

U. S. S. STRINGHAM, TORPEDO-BOAT DESTROYER UNDER CONSTRUCTION AT WILMINGTON, DEL.

Work is well advanced on the torpedo-boat destroyer Stringham, under construction at the yard of Harlan & Hollingsworth, Wilmington, Del. This boat, it will be recollected, is one of three for which contracts were let by the Navy Departmen in July, 1897. The other two boats are the Bailey and the Goldsborough. Our engravings show the condition of the vessel, which has been all plated, and the installation of the machinery is now going forward.

The general dimensions of this vessel are:

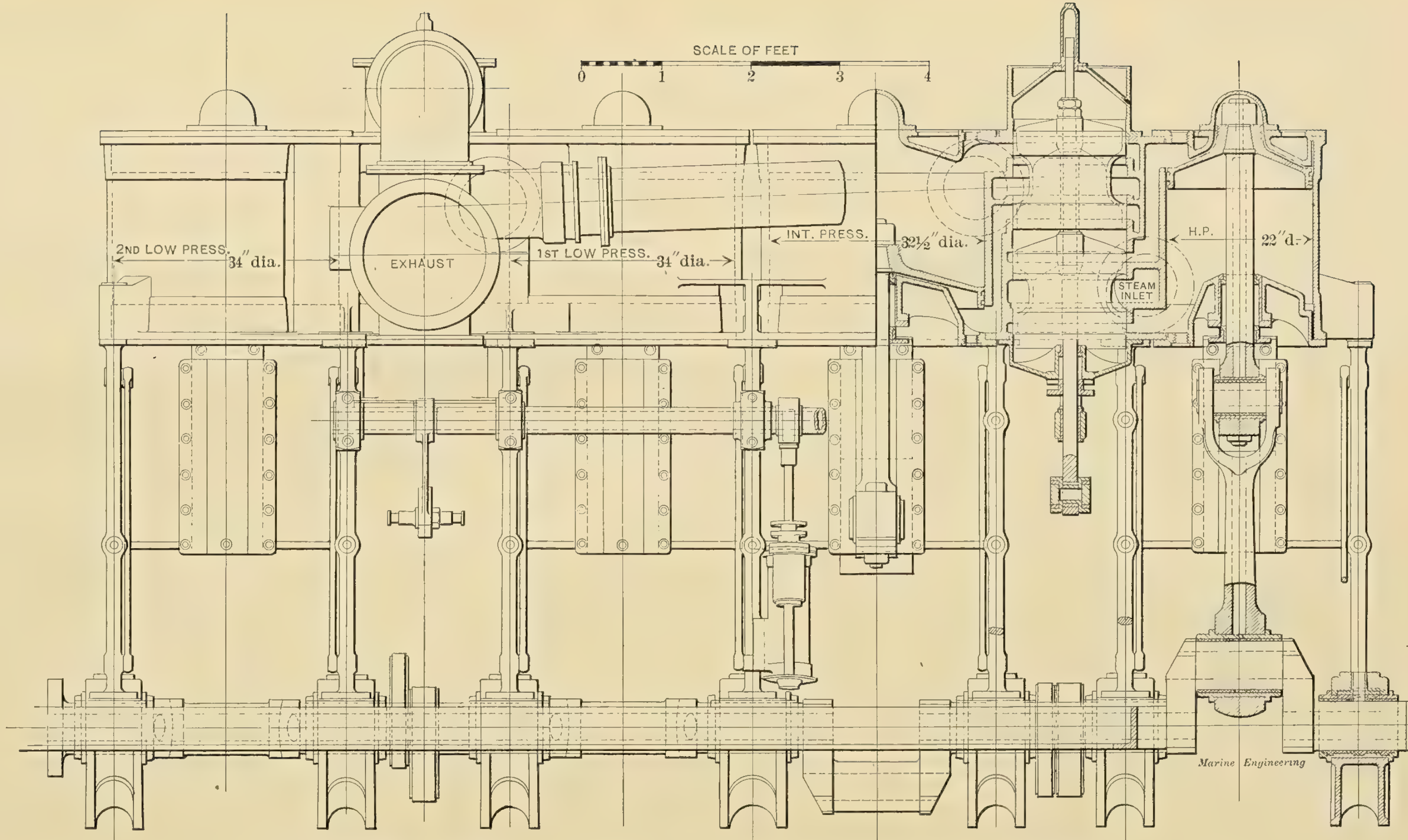
Length over all	231 ft. 4 in.
Length on normal load water line	225 ft. 0 in.
Beam, normal load water line	21 ft. 3 in.
Beam moulded	22 ft. 0 in.
Depth moulded at side	15 ft. 0 in.

Her guaranteed speed on two hours' trial is 30 knots, with trial load of 60 tons and with a displacement of 340 tons. Both her outlines and the general arrangement are shown in the drawings on page 24.

She is fitted throughout with transverse and water tight bulkheads and water tight doors. Williamson Bros. steering gears are operated both by hand and steam from the forward and after conning towers. There is also hand and steam steering gear on the bridge abaft the forward conning tower, and an emergency tiller fitted to the rudder head above main deck. There is also a Hyde steam capstan windlass for wire cable.

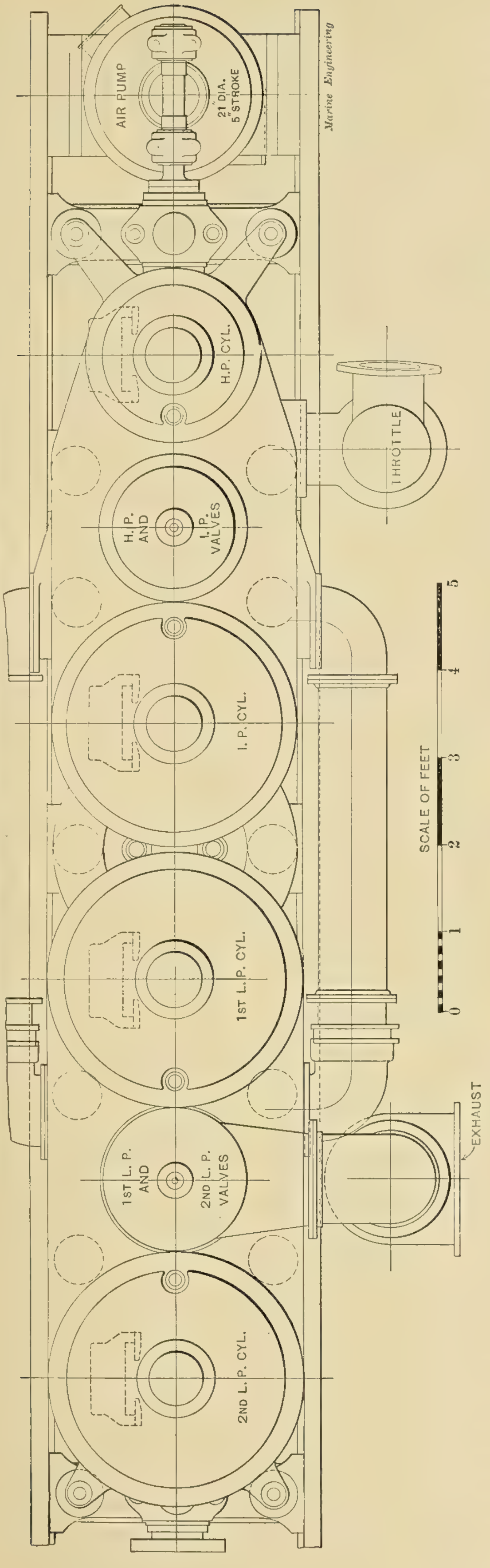
The Stringham will be armed with two torpedo tubes, one placed about amidships and the other aft; both being located so as to bear on either side, and the latter also astern. She has also seven 6-pounder machine guns, so placed that six of the seven can be brought to bear on either side simultaneously, and have a range of about 140 deg. Five of these guns are mounted on the main deck and one each on the two conning towers. As an additional protection to the conning tower, there is an armored turtle back extending from the forward conning tower to the stem, and this is supplemented by a fixed gun shield extending from the turtle back deck aft about 14 ft. on each side of the forward conning tower, about 3 1-2 ft. high, affording great protection against rapid fire guns and small arms. As the Stringham's 6-pounders are machine guns and capable of firing many shots a minute, it will be seen that her broadside is formidable for a ship of her size.

A novel feature of design in this boat of interest to engineers is the arrangement of steam valves in the main engines, as can be readily seen in the accompanying scale drawing on page 22. The propelling engines are alike, right and left, and stand side by side in one compartment. They are of the vertical, inverted, direct-acting, triple-expansion type, each with a high pressure cylinder 22 in. dia., an intermediate pressure cylinder 32 1-2 in. dia., and two low pressure cylinders 34 in. dia., the stroke of all pistons being 18 in. Stephenson link motion is used, each pair of eccentrics imparting motion to the valves of two cylinders. This is accomplished by placing the piston valves tandem so that in each engine the high pressure



FOUR-CYLINDER TRIPLE-EXPANSION ENGINES OF THE TORPEDO-BOAT DESTROYER "STRINGHAM."

and intermediate pressure valves are worked by one rod, and the same also with the two low pressure cylinders. This, of course, not only does away with the necessity for four eccentric sheaves, additional to those in the design and the necessary rods and links, but also permits a very compact fore and aft arrangement of the engines. The piston rods are fitted with single slipper cross heads working in guides bolted to the turned steel columns. The framing throughout is of vertical forged steel turned columns well stayed with diagonal braces. The engine bed plates consist of steel castings for each bearing fitted between two steel angles of 6 1-2 in. by 4 in. by 3-4 in. material, planed true on the faces, and supported on keelson plates, carefully and strongly worked into the framing of the vessel. The high pressure cylinder is forward and the low pressure cylinders aft in both engines. The



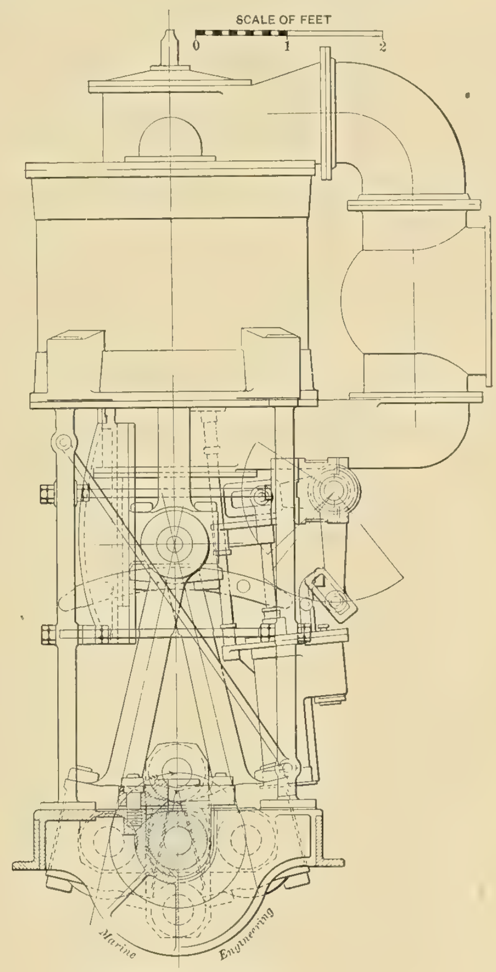
PLAN OF TRIPLE-EXPANSION ENGINES OF THE TORPEDO-BOAT DESTROYER "STRINGHAM."

crank shafts are steel, made in one piece for each engine and are hollow. The shafts, piston rods, connecting rods, and working parts generally, are forged of a high grade of steel. The piston rods and connecting rods are hollow and oil tempered.

The collective indicated horse power is estimated at about 7,200 when the engines are making about 400 revolutions per minute.

The electric lighting plant has a capacity for 100 lights.

There are two condensers, one for each engine, of copper, oval in shape, 12 ft. 9 in. long, containing 1,292 tubes 5-8 in. dia., with a cooling surface of 2,700



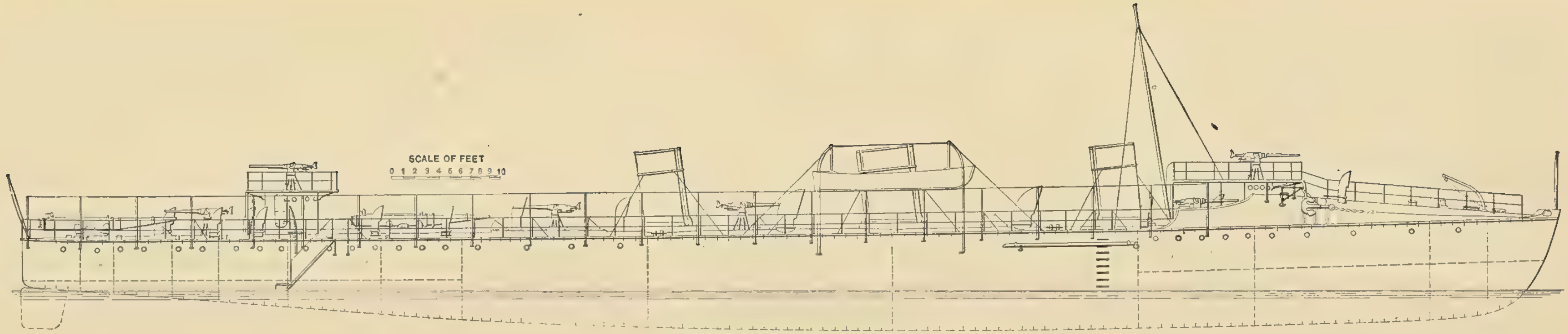
STARBOARD ENGINE
LOOKING FORWARD

ELEVATION OF "STRINGHAM'S" ENGINES.

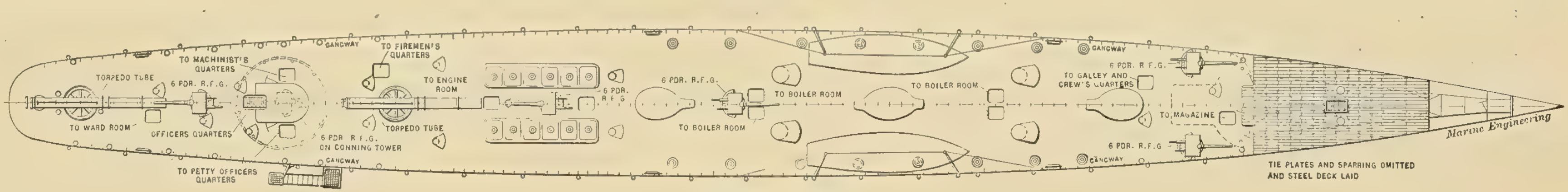
sq. ft. in each. A single acting air pump is fitted for each engine, driven from an extension of the main engine shaft. The circulating of water through the condensers will result from the speed of the vessel.

A small circulating pump driven by a small engine is fitted for slow speed and starting. The propellers are right and left, and are made of manganese bronze. There are four water-tube boilers of the Thornycroft type, with uptakes to three smoke pipes, one each for the forward and after boilers, the other for the two middle boilers.

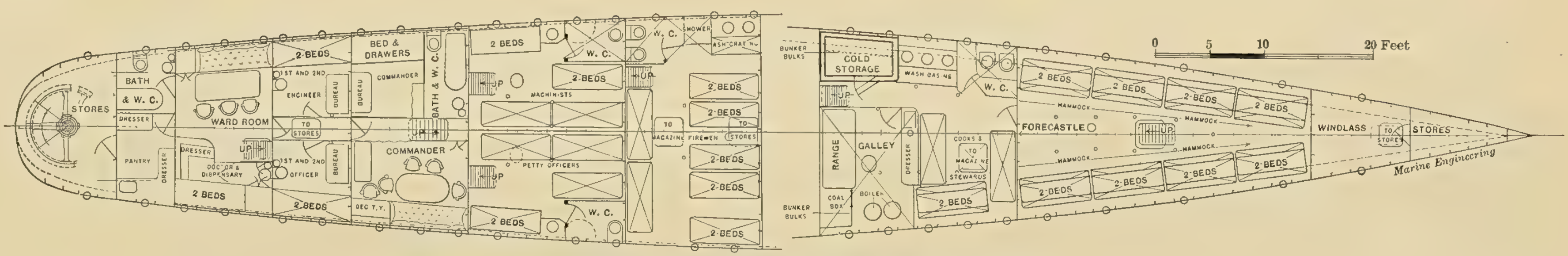
There are three steam feed pumps in the engine



OUTBOARD PROFILE.



DECK PLAN.



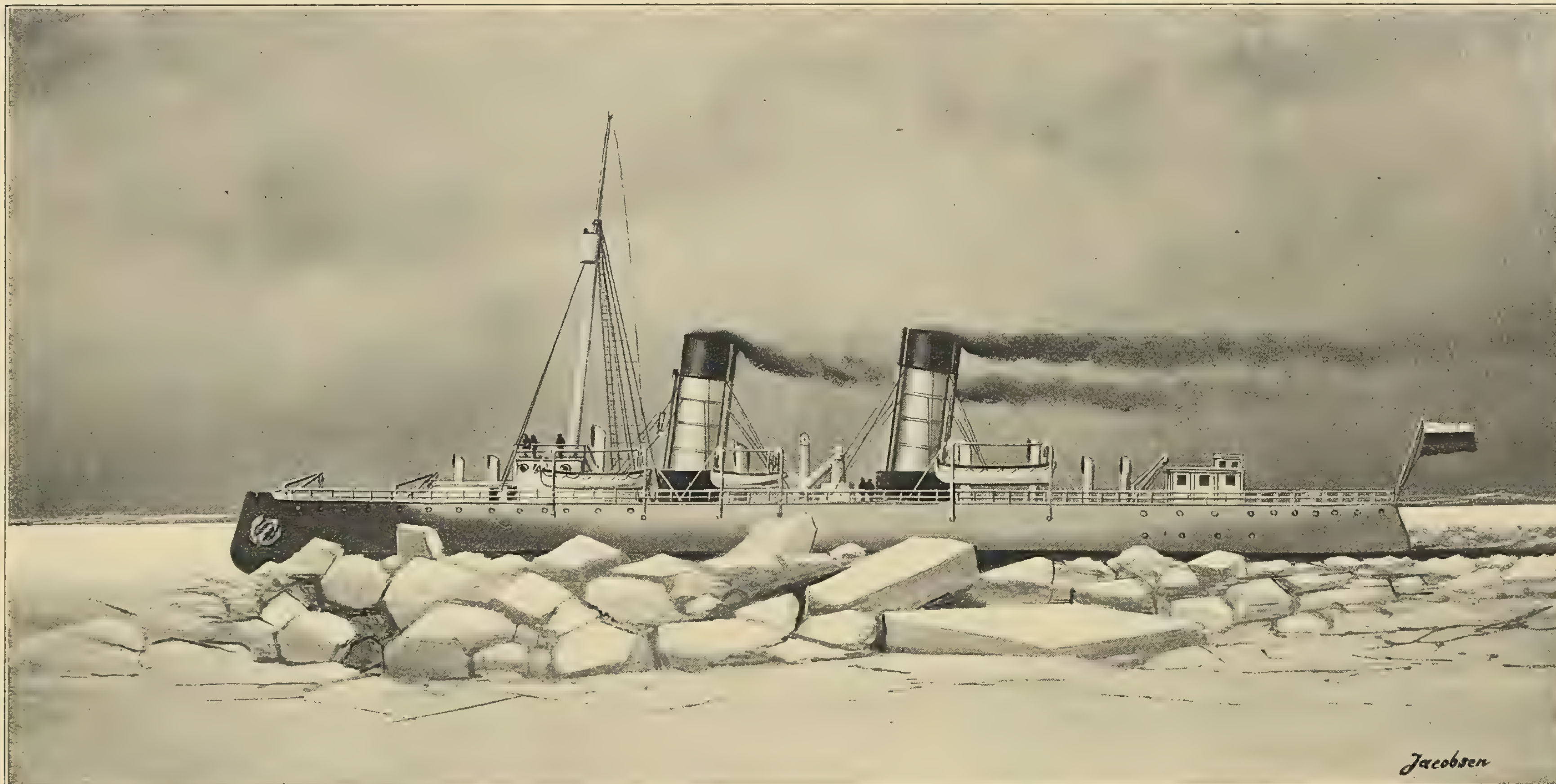
BERTHING ARRANGEMENT AND CABIN PLAN.

PLANS OF THE U. S. TORPEDO-BOAT DESTROYER "STRINGHAM," BUILT AND ENGINED BY HARLAN & HOLLINGSWORTH, WILMINGTON, DEL.

room, any two of which will have capacity enough to feed the boilers at full power. There are also fitted two blowers for the forward fire room and two blowers for the after fire room. An evaporator is fitted capable of making 3,500 gallons of fresh water for boiler use in 24 hours, and a distiller for potable water able to produce 900 gallons per day.

Ample accommodations for officers and crew are provided, with baths for officers and showers for the petty officers and enlisted men.

The complement consists of a commanding officer, two deck officers, two engineer officers, one surgeon, eight line petty officers, eight machinists, fourteen firemen, six cooks and mess attendants, and twenty-one enlisted men in the deck force, or 63 in all.



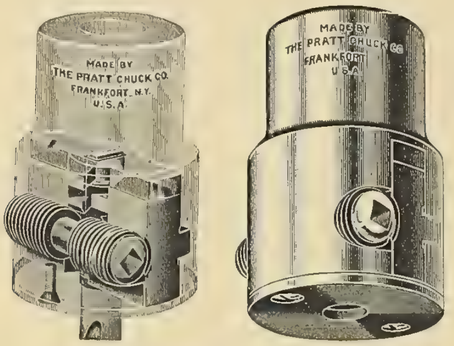
RUSSIAN QUADRUPLE SCREW ICE BREAKER "ERMACK," BUILT IN ENGLAND BY ARMSTRONG, WHITWORTH & CO.

Some time ago a commission composed of Russian shipbuilding experts visited our Lake ports where ice breaking vessels are employed and made a careful examination of the famous Lake ice crushers. Experiences elsewhere were also sought with a view to the design of a powerful vessel for use in opening up channels in various Russian ports during the depth of winter. The practical result was the placing of an order with the English firm of Sir W. G. Armstrong, Whitworth & Co. for the construction of the vessel which our artist has depicted forcing a passage through the solid ice. The new vessel is named the Ermack, and is in dimensions: Length, 350 ft.; beam, 71 ft.; depth, 42 ft. 6 in. She is fitted at the bow and stern with screws driven by four sets of triple-expansion engines of 10,000 I. H. P. in the aggregate. There are six double-ended boilers fitted with Howden draft and a complete equipment of auxiliaries, and extensive electric light plant. The construction throughout has been exceptionally strong, not only in the hull, but in the engines, so that there is but remote danger of disaster from the intended uses of the vessel. The frames are fitted very closely together and there are nearly fifty watertight compartments in all. The Ermack will have a draught of 25 ft. and a corresponding displacement of 8,000 tons.

IMPROVED APPARATUS.

Positive Driving Drill Chuck.

The accompanying cuts are exterior and interior views of the Positive Driving Drill Chuck, made by the Pratt Chuck Company of Frankfort, N. Y. The distinctive feature of the tool is an equalizing driver which takes the flattened shank end of the drill, or



POSITIVE DRIVING DRILL CHUCK.

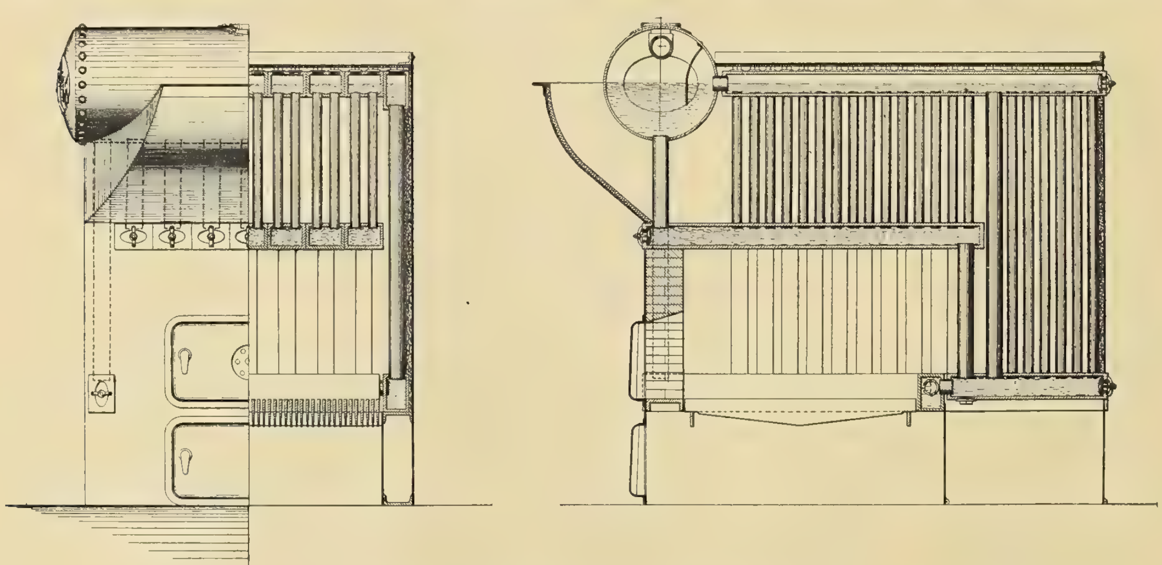
or other tool. This driver consists of a cross bar pierced with a rectangular socket hole, indicated in both figures, lying in the base of the chuck. By the use of this device the jaws of the chuck have only to hold the working tool in perfect alignment, and are wholly relieved of the twisting strain of driving the tool as well. The end of the tool shank need not be accurately or centrally flattened, as the body of the chuck is hollowed out to a sufficiently loose fit about the driver to allow any such imperfect shank to find the socket, and be positively driven by it. The makers claim it is impossible for a tool to slip, and the jaws need be tightened only enough to allow the tool to float—a handy feature when the chuck is in use on worn lathes where the turret holes are out of line. The chucks are made in five sizes.

Hutchinson Water-tube Boiler.

A new marine water-tube sectional boiler, with vertical tubes, is shown in the drawings of a small boiler of this type, which in dimensions is 6 ft. long, 4 1-2 ft. wide, and 6 ft. high, and has about 350 sq. ft. heating surface and 10 1-2 sq. ft. grate surface. The idea in designing this boiler was to create a type in which all tubes should be straight and accessible; which should have a large combustion chamber, a low center of gravity, and an obstructed horizontal path for the products of combustion. The construction is entirely of rectangular manifolds connected together and to a steam and water drum by straight tubes, in all cases secured by expanded joints. All the sections above the grates are exactly similar, making it possible to establish two or three standard side elevations, for different lengths of grate, and to obtain any required H. P. by varying the width of the boiler. The outside sections are extended down so that the water boxes form very desirable edges for the grate and the tubes make good walls for the furnace. It is intended to use for manifolds solid cold drawn rectangular steel tubes about 7-16 in. thick and in no instance larger than 6 in. sq. inside. In the design an unusually large primary combustion chamber is provided and the secondary combustion chamber is eliminated entirely. The address of the patentee is Richard Hutchinson, Tremont Building, Boston, Mass.

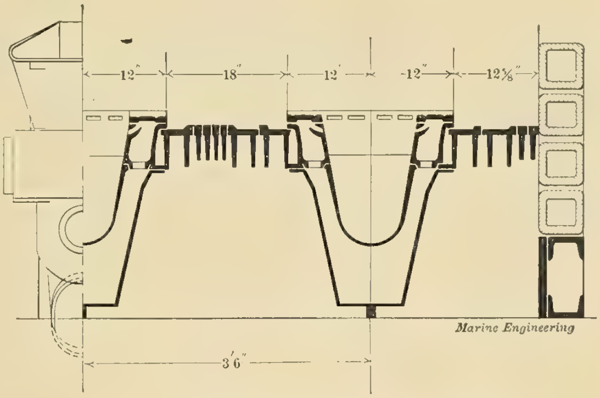
Mechanical Stoker for Marine Work.

To design a mechanical stoker which will be effective when applied to a marine boiler has been the effort of many inventors. In the case of the American Stoker Company this has reached the stage where a practical trial in a large vessel has been decided upon, with the co-operation of the owuers. The drawings here published give an idea of the construction of this stoker, which is to be fitted in a new vessel for the Zenith Transit Line, of the Great Lakes, now building at the yard of the Cleveland Shipbuilding



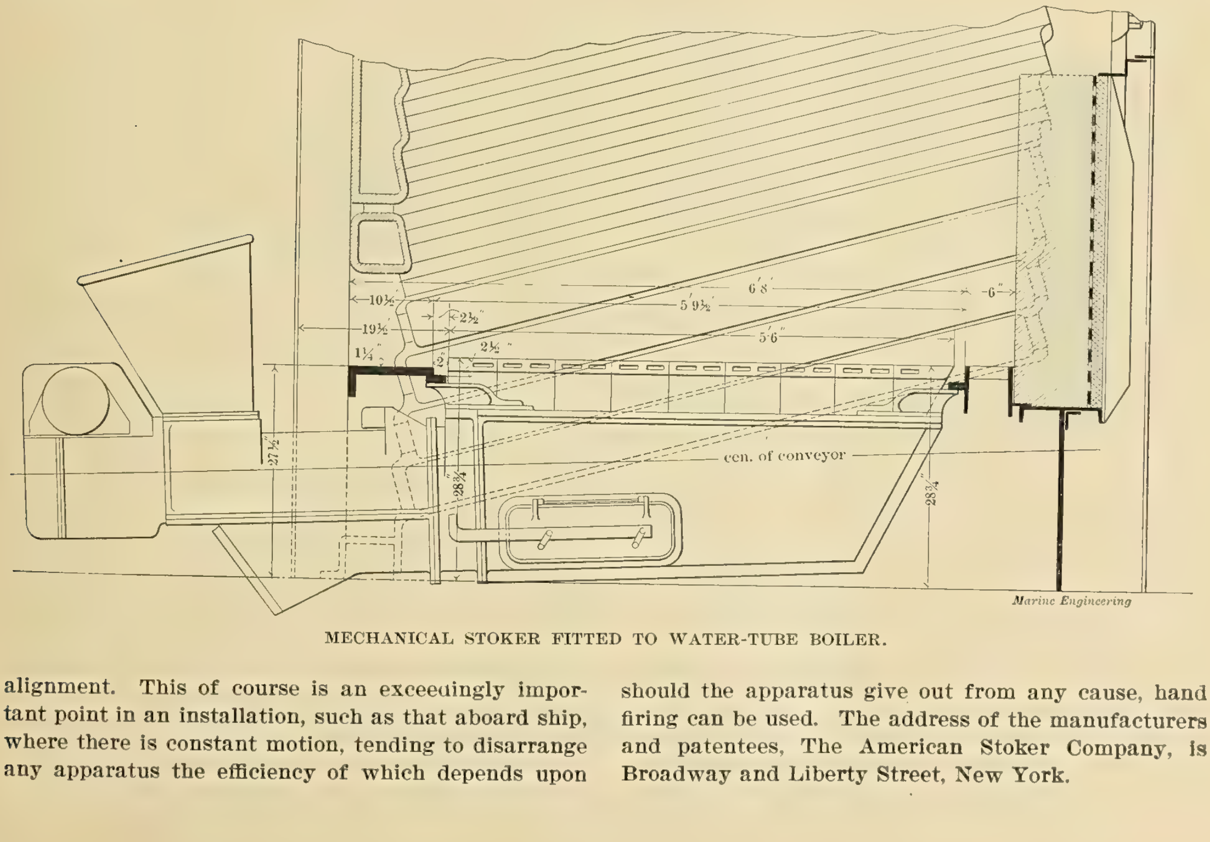
HUTCHINSON MARINE TYPE WATER-TUBE BOILER.

Company. The vessel will be fitted with two water-tube boilers, 12 ft. 5 1-2 in. long and 9 ft. 2 in. wide, fitted in a fore and aft direction with the furnace fronts inboard. The stokers will be used in connection with a system of forced draft supplied by a fan placed aft of the boiler, and connecting with the stokers by ducts under the floor plates. There will be three stokers to each boiler, or six in all, of the size known in land practice as 9 in. Each will be fitted with an independent motor and will have two dead grates. Each group of stokers is designed to burn 1,600 lb. of coal per hour nominally, and 2,100 lb. when forced, and the company guarantees an entire absence of smoke when running. These stokers are simple in design and belong to the underfeeding type. Just in front of the furnace door is a chute which may be fed by hand, as it is in the present case, or mechanically and automatically, as is the case with many installations on shore. In front of this is a small motor which serves to actuate the screw of a conveyor, which carries the coal into the furnace and distributes it up through the guide chamber to the top of the fire, therefore accounting for its name, "underfeed." This screw conveyor or worm extends the entire length of the furnace. Immediately beneath the conveyor pipe is located the wind box. The motor driving the worm has a simple reciprocating motion, having a rod which carries a crosshead, and which, by means of suitable connecting links, operates a rocker arm with a pawl mechanism, that in turn actuates a ratchet wheel attached to the conveyor shaft. The stoker is thus entirely self-contained and complete in itself and consequently there is no danger of the driving and feeding mechanism ever getting out of its correct alignment. At the boilers the coal is fed into the hopper, carried by the conveyor into the magazine or furnace, which it fills, overflows upon both sides, and spreads upon the sides of the grates, as may be understood from the smaller drawing showing the front elevation and section of two stokers of one boiler. The coal is fed slowly and continuously, and approaching the fire in its upward course is slowly roasted and coked, and the gases released from



TWO OF THREE STOKERS FOR ONE BOILER.

it are taken up by the fresh air entering through the passages, which combines these gases, the coal being delivered as coke on the grates. The cleaning of the grates or the removal of the ashes is easily performed and entails no loss, since the coal in its passage has been thoroughly consumed. The boilers will be fitted with furnace doors, and ash pan and doors, so that



MECHANICAL STOKER FITTED TO WATER-TUBE BOILER.

alignment. This of course is an exceedingly important point in an installation, such as that aboard ship, where there is constant motion, tending to disarrange any apparatus the efficiency of which depends upon should the apparatus give out from any cause, hand firing can be used. The address of the manufacturers and patentees, The American Stoker Company, is Broadway and Liberty Street, New York.

MARINE ENGINEERING

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THE event of the month in shipbuilding circles was the launching of the monstrous White Star liner Oceanic at the yard of Harland & Wolff, Belfast, Ireland. In another place in this issue a general description of the new vessel is given, together with reproductions of photographs of the vessel before, during and after the launching, taken expressly for the information of our readers. Aside from mere comparative size, there are many ideas of the owners incorporated in this vessel which are of particular interest. Punctuality, if such a word can be properly used with reference to the schedule arrival of an ocean liner, has been a controlling factor in design rather than record-breaking capacity. In this the White Star line has departed from traditions, just as it did in the past in the matter of form and in interior arrangement of its ships. So accustomed, indeed, had persons interested in such matters become to the rivalry of lines in the matter of speed, that when the vessel was projected the wildest guesses took the form of positive statements—about 27 knots was the limit. But viewing their trade and its possibilities, the owners decided that in their new vessel speed should be subordinated to punctuality, comfort, carrying capacity, safety and commercial success. To be assured of the first a set of dimensions was decided upon, which gave the largest vessel in existence, built or building; a vessel large enough and powerful enough to be able to maintain a high rate of speed in storm as well as calm. Keeping the engine power within limits in such a huge and heavy structure meant freedom from irritating vibrations—therefore comfort. Care in design and honest work in construction provided the factor of safety, and the proportion of machinery and bunker to cargo and passenger space, and the keeping of power within economic limits, assures profitable financial returns. It is certainly a strong argument in favor of those who hold that under existing trade conditions and the present limits of scientific knowledge the end has been reached, if not passed, in liner construction. A moderate increase in speed over existing ships would not have brought the company more popularity among discriminating travelers, though it would undoubtedly for the time attract those (and they are many) who want to travel in the fastest ship. The Oceanic as designed will end her transatlantic trips on Wednesday mornings, thus getting alongside her dock at a seasonable and convenient hour, and, if delayed through fog or otherwise, will have a margin of several hours in which to land her passengers in daylight. Greater hourly speed would mean possibly an arrival Tuesday afternoon or night, in which case the time saved to the passengers on the voyage would be lost in port, especially for those making through connections. To get in Tuesday mornings would mean what is really an enormous increase in speed, with all its attendant cost and discomfort.

RETURNS of British shipbuilding during the year 1898 are recorded in various foreign papers, along with many expressions of congratulation upon the prosperous showing during the year ended and the indications for the year begun. In round numbers the total tonnage launched from private yards in the United Kingdom was 1,600,000 tons, or an increase of about 500,000 tons over the preceding year. At the head of the list in point of total output comes the English east coast yard of Sir W. Gray & Co., with 72,323 tons. The Scotch record was captured by Russell & Co., of Port Glasgow, with 44,551 tons, and in Ireland Harland & Wolff lead with 67,905 tons. Had they launched the Oceanic during 1898 they would have exceeded all British firms, as they did in 1897. The output of all yards outside of the United Kingdom is estimated at about 500,000 tons, so that this gives British yards the credit of putting out three-fourths of the world's shipbuilding during 1898. At the Royal Dockyards naval vessels of a total of about 71,000 tons were put out, and in private yards vessels built for the British Navy reached a total of about 70,000 tons, the value of all being about $43,450,000. For foreign governments there were launched in 1898 from British yards 52,365 tons of a value of about $17,500,000. This was formerly a class of trade exclusively in British hands, but it is now being cut into by German builders and to some extent by our shipyards.

WE publish an extract from an address by Daniel C. Gilman, LL.D., President of Johns Hopkins University, delivered recently at the opening of the new Library building of Princeton University. The subject chosen by the distinguished speaker was "Books and Politics," and, in his reference to science as contained in the books, he said:

Let me draw from current affairs some illustrations of the highest service that libraries can render to the community in which they are placed. Proceed to the Brooklyn Navy Yard and ask leave to visit a battleship or armored cruiser. Place yourself, if permitted, under the guidance of a naval officer. Listen to his story of how the ship was designed, constructed, protected, armed, equipped, navigated, carried into action and brought out of the terrific fire unscathed and victorious. In the aggregate and the detail you will see the results of applied science more impressive than any of the seven wonders of the world. As illustrations of human power, the Pyramid of Cheops, the Dome of St. Peter's, the great bridges, the continental railways, the Eiffel Tower, take secondary rank when compared with a battleship. Every branch of physical science has contributed to naval architecture. Mathematics, mechanics, electricity, chemistry, metallurgy produced the tremendous enginery of the Oregon, able to ride upon stormy waves and encounter the cyclone unharmed, double Cape Horn without replenishing its coal, discharge its explosives with consummate accuracy, destroy the enemy and protect the lives and limbs of officers and crew. Whence is this applied science derived? From thousands of years of research and record. Mathematics begins with theorems as old as Euclid; steel with the earliest extraction of the ore; the luminous elektron of primeval men was the dawn of electricity; so, in every department, the work of many generations has accumulated. And where is this knowledge stored up? It is perpetuated and augmented in libraries; it is taught in colleges, schools of science and naval academies; by its acquisition "the man behind the gun" is disciplined in accuracy, coolness, memory, ingenuity, judgment and intellectual strength.

This is a worthy tribute, indeed, to the dignity and capability of the constructive and operative branches of our Navy, and it comes, too, with the authority of ripe scholarship and intellectual force. This might well be seriously considered and applied by those who have the future of the American merchant marine within their possibilities of action.

IN the pages of our London contemporary, *The Shipping World,* we note a statement with reference to the shipbuilding year that "the record output for the year goes to an American firm, the Newport News Shipbuilding and Dry Dock Co., having the truly magnificent total of 80,225 tons to their credit." Then are enumerated the battleships Kearsarge, Kentucky and Illinois, the Missouri, the Arkansas and six vessels, each of 5,000 tons. In the interests of truth and statistics we regret to have to say that the "record output" did not go to an American yard. As a matter of fact, the output of the yard named was not anywhere near the figures given. Or does our contemporary mean by "output" vessels in the draughting room or in an uncompleted state on the slips. The battleships Kearsarge, Kentucky and Illinois were launched during 1898, while contracts for the construction of the Missouri and Arkansas were only signed on October 11, 1898. Of the other vessels not one was completed in 1898. If these ships are to be counted in the "output" why not, for example, include the Oceanic in the output of Harland & Wolff? It may be some consolation to our contemporary to know that very probably the statement will hold good a year hence, considering the amount of orders in the yard referred to and the prospects for American shipbuilding.

DELEGATES from the local organizations of the Marine Engineers' Beneficial Association held their twenty-fourth annual convention at Willard's Hotel, Washington, D. C., last month. There was a good attendance and close attention was given to the matters brought up for discussion. Among these was the revision of the constitution, which was so arranged as to enlarge the powers of the branch associations. A clause was also inserted permitting the smaller organizations (having less than fifty members) to join together in sending representatives to the convention. Election of officers resulted in the following being chosen: George Uhler, of Philadelphia, National President; Frank Jones, of San Francisco, National Vice-President; George A. Grubb, of Chicago, National Secretary, and B. Blanchard, of Milwaukee, National Treasurer. Members who will sit on the Advisory Board are: John Steritt, of New York; Joseph Brooks, of Philadelphia, and Joseph Brady, of Baltimore.

EXCERPTS FROM ANNUAL REPORT (1898) OF THE ENGINEER-IN-CHIEF, U. S. N.

Always an interesting document, the Annual Report (1898) of George W. Melville, Engineer-in-Chief of the Navy, recently issued, is of special interest this year. War experiences gave much opportunity for getting a line on the efficiency of various forms of apparatus which had not previously been subjected to war tests. Besides such information the report contains much that is not strictly naval matter, but applicable equally to the merchant marine interests, and is of widespread technical interest. That our readers may have the benefit of this concentration of experiences we publish the following lengthy excerpts:

One very important item of information was obtained from the long and severe services of the ships in tropical waters, and that was the urgent necessity of keeping a large fresh-water supply available for them. The evaporating plants, as usually found sufficient in ordinary cruising, proved inadequate to continuously meet the demands for fresh water there made so unusually heavy and due to conditions imposed by the hot climate. The high temperature of the sea water which is used for condensing the steam from the evaporators reduces the output of these plants to far below the normal, and the serious results from this were shown in salting up of boilers, dropping of furnace crown sheets, and, in some cases, the destruction of boiler tubes. As the very life and efficiency of a steamship lies in the ability to keep her boilers free from heavy scale, it became a matter of greatest moment to send to the fleet ships fitted especially for distilling water in great quantities; vessels that could follow the squadron and supply the daily deficiencies of fresh water wherever they might go.

* * *

Barring the torpedo boats, which will be discussed later in this report, there was a remarkable absence of casualty in the machinery departments of the vessels of the fighting squadrons during the period of the war. Even in action, when forced-draft conditions were in operation, and the excitable natures of the men most wrought upon by the surroundings, the reports show that the machinery not only worked well generally but that in no case was it greatly distressed. This is as fine a commentary upon the personnel as on the machinery.

It is greatly to be regretted that the torpedo boats can not show the same excellent records for their machinery, but it is a sad fact that nearly every one has had some accidents, and the machinery of some at the close of the war was in a condition which can only be described as horrible, where boilers were burnt, cylinder covers broken, pistons and valves stuck, and everything in bad shape. This condition of affairs seems attributable to two causes, the absence of trained engineering supervision and the use of the boats for duty to which they were not adapted.

Before the war the experiment (and it was understood to be an experiment) was attempted of running the torpedo boats with only one trained engineer officer for the whole flotilla, leaving the care of the machinery of the individual boats to young line officers, who had this as a part of their multifarious duties. It is not their fault that they are not trained engineers, and undoubtedly they were faithful in their efforts to perform their duties, but they had not been through the preliminary training which will come with the passage of the personnel bill, and a man without previous training does not become at once a skilled engineer by assuming charge of machinery.

This experience with the torpedo boat is, indeed, an excellent illustration of the benefits to be anticipated from the passage of the personnel bill. Only a very few officers can be carried, but when every one is an engineer by education and training, there is an assurance that these machines will have trained supervision and be kept in good order.

As to the second cause, it did not require this experience to prove that this type of vessel cannot be safely used for dispatch-boat duty and to act as tenders on blockading ships far from the base of supplies or facilities for efficient repair. Primarily, they are intended for high-speed spurts where success or failure in the use of their special weapon shall be quickly demonstrated. For this they are especially built and for this they should be solely kept.

INSPECTION OF MATERIAL.

The material inspected consisted of steel forgings; steel, iron, and brass castings; steel boiler plate, boiler bracing, angles and shapes; lap-welded and seamless steel boiler tubes and steam and water pipe; lap-welded charcoal iron boiler tubes and pipe; brazed and seamless copper and brass pipe and tubes; steel rivets and rivet rods, and finished articles in steel and brass for fittings for engines and boilers; structural steel and plates for the Bureau of Yards and Docks; and anchors for the Bureau of Equipment.

The specifications have been revised to secure the benefit of the progress made in the manufacture of steel, iron, copper, and brass material, the plan now being to write specifications for each class of material to cover the requirements of all classes of vessels, thus avoiding the confusion resulting from the multiplicity of separate books for each kind or lot of vessels. The manufacturers have been consulted about these changes, and the aim has been to write the specifications in such a way that the expense of testing is made as small as possible compatible with the assurance of getting the best material for the purpose intended.

Nickel-steel engine forgings have been brought to a high degree of perfection, and the only regret is that so few companies have undertaken to do this class of work, but the prospect is that in the near future several more steel companies will begin to make them.

Seamless drawn steel boiler tubes have been furnished during the year for all classes of our boilers of a degree of excellence undreamed of a few years ago, and in consequence the lap-welded tube makers have been compelled correspondingly to improve their product, both in material and workmanship.

The securing of a suitable material for steam and feed pipes in the destroyers and torpedo boats became a vital question, owing to the fact that at the temperatures corresponding to the high pressures carried copper and brass, which have hitherto been employed, lose a large percentage of their strength. The difficulty has been overcome by the advent of seamless drawn-steel pipes, with wrought-steel flanges welded on, which are now made with a degree of perfection which makes them absolutely safe.

When it was decided that the new battleships should be practically identical with the Alabama class, and that no hull changes would be made, it became necessary to find a way to reduce the thickness of the shell plates for cylindrical boilers. The shell plates in the Alabama class had reached a thickness of 1 7-16 in. in material having a tensile strength of over 65,000 lb., an elastic limit of over 35,000 lb., and an elongation of 24 per cent in 8 in. for longitudinal specimens.

Experiments have been made on a higher-carbon steel, oil tempered and annealed, which has a tensile strength of over 74,000 lb., an elastic limit of over 40,000 lb., an elongation of over 21 per cent, with a very satisfactory transverse cold-bending test. Such material allowed a slight reduction in thickness from that used in battleships Nos. 7, 8, and 9, although the boilers were designed for the higher pressure called for in the new battleships.

Nickel-steel bracing and rivets have been made and tested and found suitable for use with this high-grade boiler plate, easily reaching the requirements of the Bureau's specifications.

Experiments have also been made with nickel steel to fill the high-grade shell-plate requirements, which gave very satisfactory physical results, with a surface much better than that furnished for the boilers of the Chicago but not as perfect as that of the high-grade carbon steel just described.

WATER-TUBE BOILERS.

In the report of last year attention was called to the increase in the use of water-tube boilers in all foreign navies, and the opinion was expressed that sufficient experience had been gained at home and abroad to warrant us in using boilers of this type in all our ships. The occurrences of the past year have served to strengthen this opinion, and the Bureau, in its recent designs, except for the battleships, has specified this type of boiler.

In view of the fact that the Department's plans for the battleships, for which contracts have just been awarded on the builders' plans, provided for cylindrical boilers, an explanation of this seeming inconsistency is necessary. The Bureau did prepare a design for water-tube boilers, which it was very anxious to use, but it having been decided that the new ships should be practically identical with the Alabama class, and that no hull changes would be permitted, it was impossible to use water-tube boilers, as that would have involved a readjustment of hull weights to maintain the trim.

Notwithstanding this temporary postponement of the Bureau's desire that all of our new ships should have water-tube boilers, the Department's circular of July 26, which encouraged builders to submit designs for higher speeds and greater endurance, made it almost certain that water-tube boilers would be secured, inasmuch as the easiest way to accomplish the desired results was by their use, and there was little doubt that the builders when given the opportunity, would submit plans for vessels as good as any in foreign navies. The bids which were received on September 1 justified this idea, and although all the bidders did not offer water-tube boilers it is practically certain that they will all install them, so that the Bureau has the satisfaction of knowing that the machinery of these new vessels will be in all respects of the most modern type, as its own specifications would have called for had not the limitations imposed by conditions external to the machinery prevented this desirable consummation.

At the present day it would be hard to find any design for the machinery of new naval vessels which does not include water-tube boilers. The demands upon the engineer for great power on small weight, in order to secure the higher speeds for all classes of vessels which are now common, have practically ruled out the cylindrical boiler on account of its weight and inability to carry the high pressure needed.

The tactical importance of water-tube boilers is also being thoroughly recognized, and has been emphasized by the conditions which obtained in our blockade of Santiago and the great victory of July 3. It was necessary for a long period that our ships should be ready to develop maximum power at a few minutes' notice, and with cylindrical boilers this involved keeping all the boilers under steam, with heavily banked fires and an attendant large consumption of coal. Water-tube boilers of the proper kind, which admit of the rapid raising of steam with safety, remove this difficulty and give the commanding officer a more complete control of his fighting machine.

Without going at length into the other advantages of water-tube boilers, which have been published repeatedly, it may be added that one very striking advantage for war vessels is that the boilers can be replaced or practically rebuilt without disturbing the decks, all parts being small enough to pass through permanent openings. This was the case in the Monterey, as mentioned last year, and it was strikingly illustrated this summer in the case of the Canonicus, Manhattan, and Mahopac, where it would have been impossible to use any but water-tube boilers without practically rebuilding portions of the hull.

It may be remarked in this connection that all of our torpedo boats have water-tube boilers, and that four large vessels, including the Monterey, are so fitted. The Chicago and Atlanta also have boilers of this type now installed. The four new monitors, for which bids will be opened October 1, will have water-tube boilers, and the sixteen destroyers have them as a matter of course.

It thus appears that, as the new battleships to be built on the contractors' plans will also use water-tube boilers, we have definitely taken the step of adopting them for all our vessels, and there can be little doubt that the efficiency of the fleet will be increased in consequence.

In water-tube boilers with straight tubes there has been thus far an unfortunate lack of economy under forced draft, but this will be avoided in the boilers for the new ships by using heaters for the air, which absorb the heat from the gases of combustion before they reach the smoke pipe and thus enable a good economy to be secured.

As was stated in the last report, there is not yet any agreement as to the particular make of water-tube boilers which is best from every point of view. Nearly every one has some feature of excellence, and it can not be doubted that, with the great amount of the best engineering talent which is working at the problem, one or more forms will finally be developed which will be thoroughly satisfactory in every way.

LIQUID FUEL.

When the last report was written, it was anticipated that apparatus for burning fuel oil would have been installed on one of the cruising torpedo boats, and experience have been acquired as to the working of this fuel in regular service. The war of course prevented anything of an experimental nature being attempted on vessels of this class, of which we had so few. It is intended after the resumption of normal peace conditions to carry out the original programme.

Last winter, however, through the cordial co-operation of the Chief of Ordnance, who is always eager to further any effort looking to an increased efficiency of the fleet, the Bureau was given control of the small torpedo boat Stiletto (belonging to the Ordnance Bureau) for several months. The fuel-oil apparatus of the Consolidated Gas Fuel Company, which had given excellent results in tests on a small scale, was installed under the personal direction of P. A. Engineer John C. Leonard, to whose zeal and painstaking work the Bureau adverts with much pleasure.

The object of the experiments was not the determination of economic values, as that side of the question has been so thoroughly investigated as to make further work of the same kind unnecessary, but to give the system a thorough trial under the conditions of regular daily service in order to ascertain its cost, reliability, and general satisfaction.

The tests under Mr. Leonard's personal direction were very satisfactory, and, although the economy was not high relatively to coal (due to the machinery which was not specially adapted to the use of oil fuel), the economy was the same as had been anticipated from previous experience. The personnel of the boat were carefully trained during these tests, and as long as they were under Mr. Leonard's supervision were efficient and seemed enthusiastic about the new fuel.

When the Stiletto returned to Newport the machinery was entirely in the hands of the crew without any engineering supervision, the boat being employed in her ordinary duties as a tender, and the system did not give satisfaction. The commandant of the torpedo station reported that the use of fuel oil was more expensive and less satisfactory than coal, and that the boat was less available and less reliable than when using coal. In view of these statements, and his recommendation that the fuel-oil apparatus be removed, it has been taken out. It would seem, however, that as the apparatus gave satisfaction when under the control of a competent officer, its failure in regular service was not due to any inherent defect, but to indifference or lack of acquaintance on the part of those who handled it. The Bureau does not consider this experience as at all unfavorable to the use of oil fuel, but anticipates that its use on a larger scale, under the direction of a skilled engineer, will prove entirely satisfactory.

There is no difficulty along our eastern coast of procuring a suitable fuel oil in any desired quantity, and representatives of firms handling this oil have repeatedly stated that in considerable quantities it can be furnished at a very moderate price. The small amount needed for the Stiletto at Newport made the price so high (over 7 cents per gallon) as to preclude its general adoption if such figures were to be the rule. The oil used had a specific gravity from 0.85 to 0.87, a flash point of about 315° F., and a burning point of about 350° F. A bunch of burning waste when plunged into it was extinguished. There can therefore be no doubt of its perfect safety for use on board ship.

THE STEAM TURBINE ON SHIPBOARD.

Although the steam turbine itself was not a novelty in engineering, owing to the skill with which its economy has been developed in England by the Hon. C. A. Parsons, its application last year to propulsion on the Turbinia was a decidedly novel step, and the remarkable performance of that little vessel of 42 tons displacement in attaining a speed of over 31 knots attracted the attention of engineers and shipbuilders all over the world. While an analysis of the published data of the performance would seem to indicate that the boiler was the most remarkable part of the machinery rather than the turbine, the fact remains that the combination enabled a phenomenal record to be made.

During the year the Bureau has been carefully investigating the adaptation of the steam turbine to naval uses, has kept informed of the progress of experiment on two forms of turbine being developed in this country, and has been represented at an economy test of one of them.

Thus far the results obtained do not warrant an expectation of the substitution of the turbine for the steam engine in the near future, but the experimental work will be carefully watched so that, should further experience warrant the use of the turbine, the service may be among the first to profit thereby.

REPAIR SHIPS.

In the last report attention was called to the desirability of making such preparation for the fitting out of a vessel which would be a floating repair shop as would enable the work to be done with great rapidity when needed. Immediately on the prospect of war the Bureau again brought this matter to the Department's attention, and the steamer Chatham was bought, set aside for this purpose, and renamed the Vulcan. The work of installing the machine tools, cupola, forges, brass furnaces, etc., was pushed as rapidly as possible, as well as the selection of a force of skilled mechanics. A large and well-chosen outfit of stores of all kinds was also supplied.

The Vulcan arrived at Guantanamo on July 1 and proved of the highest usefulness to the fleet, making repairs of all kinds and furnishing much needed supplies to every department of nearly every vessel. At the end of August reports from her officers showed that she had made repairs to 63 ships and had supplied stores to 60. Her unusual facilities and the large number of skilled mechanics on board (about 100) enabled her to make repairs of all kinds, including hull work, gun mounts, dynamos, main steam pipes, main piston rods (for small ships), brass castings without end, and iron castings in considerable quantity. This last is specially interesting as the first instance of the successful use of a cupola on shipboard.

DISTILLING SHIPS.

It was evident, as soon as the fleet began to assemble in the Gulf, that some provision must be made for supplying an adequate amount of fresh water for the boilers, as the distilling plant ordinarily supplied is not large enough to furnish all the fresh water needed for personal uses, and also the extra feed consequent upon losses in the machinery, except at very moderate powers.

A multiple-effect evaporating machine, which would be able to give more than 20 lb. of fresh water for each pound of coal burned in the boilers evidently was the most satisfactory solution of the question, as a vessel with such apparatus of 50,000 or 60,000 gal. per diem, and with a coal capacity of, say, 3,000 tons, would be able to supply an amount of water equal to a large number of tank vessels. Such a vessel would also have the further advantage that she is practically a collier at the same time, and should there be an emergency in which coal was needed more than water, her large supply of coal could be utilized for that purpose instead of distilling.

As already stated elsewhere in the report, two vessels were purchased and converted into distilling ships. Unfortunately, the work of constructing the apparatus required so much time that neither was completed before the active operations of the war had closed. The Iris, however, was finished in time to enable her to be sent to Montauk Point to supply fresh water for drinking purposes to the army there.

A distilling ship is, in my opinion, of vital necessity for a fleet of any size, and I believe that we should keep these two vessels in good order at all times, and ready to be sent with a fleet whenever it is likely to operate where it would be difficult or expensive to obtain fresh water. The cost of supplying water with these economical plants is very much less than water can be purchased anywhere, except under the most favorable circumstances, such as at large cities, where vessels can go alongside the dock and take water from the city mains.

While it was of first importance that cylindrical boilers should have fresh feed only, it is absolutely necessary to the integrity of water-tube boilers that they should never use anything else, and this involves an increase in the evaporating plants of ships fitted with these modern boilers, and provision for the storage of an adequate amount of fresh water in the double bottoms or in special tanks. The universal practice of the merchant marine in using the double bottoms for this purpose shows its entire practicability. The distilling ships will furnish this extra water in the most economical way.

THE OREGON'S PERFORMANCE.

It has not been customary to call special attention to the performance of vessels except on trials under maximum conditions, but that of the Oregon is so exceptional that it deserves a record in the Bureau's report. She was ordered from the Pacific to the Gulf before war was declared, and, leaving Puget Sound March 6, arrived at Jupiter Inlet May 24, having steamed over 14,500 miles, stopping only for coal, and not being delayed an hour anywhere through any derangements of the machinery. Stopping at Key West only long enough to coal, she took her place in the blockading fleet at Santiago, and was always ready for service.

This alone would have given her an unparalleled record among battleships, but the culmination came in the great battle of July 3, when she surpassed herself. Always ready for action, she speedily attained a power greater than that developed on the trial, giving a speed (on account of greater displacement and foul bottom) only slightly less than then attained, and distancing all the other ships except the Brooklyn, which is 5 knots faster. Every official report comments on her wonderful speed, and it is generally believed that but for it one at least, and possibly two, of the Spanish ships might have escaped.

The whole record is thus one which has never been equaled in the history of navies, and it will remain the standard for a long time to come. The credit is due, in the first place, to the builders—the Union Iron Works—for the excellence of the material and workmanship, but still more, and chiefly, to the engineer department of the vessel. The Bureau, therefore, takes great pleasure in commending to the Department's more favorable consideration Chief Engineer Robert W. Milligan, the executive head of the department, for his professional ability, untiring care and excellent discipline; and also the junior engineer officers and the enlisted men, whose faithfulness and zeal, under most trying circumstances, have enabled our Navy to add this to the other brilliant records of our vessels.

VOLUNTEER OFFICERS.

The wholly inadequate number of regular officers of the Engineer Corps for the proper performance of duty even in times of peace made it necessary to have recourse to a large number of volunteers when the war brought about such a great increase in the number of vessels. Every regular officer on the active list who could be sent to sea without positive injury to the public interests was so detailed, their places on shore being filled chiefly by retired officers and in some cases by volunteers. It was felt to be of vital importance that our fighting ships should have the regular officers, whose thorough discipline and training would insure maximum results from the machinery, and this policy was systematically followed. In many cases, however, the complements had to be brought up to the proper numbers by volunteers.

In the appointment of these volunteer officers every effort was made to get men who had a thorough mechanical education and, where practicable, sea experience. In the case of the younger men this last was of course usually impossible, but they had usually received a superior technical education and were familiar with machinery. While it can not be claimed that all were of immediate value, the reports received show that, as a rule, they entered upon their duties with great zeal and did everything possible to make themselves useful and efficient officers. A large percentage are splendid types of highly educated and patriotic Americans of whom the country may justly be proud, and who reflect credit upon our great technical schools from which they graduated.

A respectable portion of the volunteers are men of the first rank in mechanical engineering, including a number of ex-officers of the Engineer Corps, who gave their services at a great personal sacrifice. To one of them the success of the repair ship Vulcan is largely due.

The present outlook is for a great increase in the demand for officers at sea, due to the increased number of ships that must be kept in commission to look after our oversea possessions, gained during the war. The number of regular officers will not begin to be adequate for this duty, and even the personnel bill, which was planned for a smaller navy, will not furnish enough officers. I would therefore earnestly recommend that the process of mustering out the volunteers be carried on so as not to reduce the aggregate number of regular and volunteer officers below that necessary for the proper performance of duty.

It is possible, and even probable, that the number of ships which must be kept in commission for some time will be such as to make it absolutely necessary to have more officers than can be furnished under the provisions of the personnel bill for some years.

In that case it may become necessary to arrange for the appointment of some of the volunteers in the regular service. This will be somewhat difficult to arrange without interfering with the personnel bill, whose importance is so great that I would hesitate to make any recommendation that might even seem to conflict. That bill assumes such a training for the young men that they can perform interchangeably duty on deck or in the engine room. This the volunteer engineers can not, of course, do at once. It seems to me possible, however, that by a careful selection of those who are young enough and have shown an aptitude for the service we may secure the necessary numbers for the immediate performance of duty with the machinery and require them, after a reasonable term, to qualify themselves for the additional duties which they will have to perform under the provisions of the personnel bill.

LESSONS FROM THE WAR.

The war which has just ended is the first in which modern steam vessels have had a thorough trial, and it seems pertinent to note the more important lessons which have been taught by our experience. With respect to the machinery they are as follows:

1. The vital necessity of giving the machinery of vessels in reserve frequent tests under working conditions, so that any defects may be discovered and remedied before war makes the vessels' services absolutely necessary. In several cases defects were found after the ships had begun cruising, and the repairs laid them up in the midst of the war.

2. The great importance of having all our naval stations in positions of strategic value properly fitted out for repairs and with adequate supplies of nonperishable stores. It had been evident for a long time that Key West was such a station, but money to put in a proper repair plant was refused year after year, and only granted after the war had begun. The movement of large bodies of troops and their equipment almost blocked the railroads, so that after the beginning of the war it was almost impossible to secure the forwarding of tools and supplies.

3. That fresh water for the boilers is almost as important as coal, and that a distilling ship is an important adjunct of a fleet operating away from a base where fresh water can be readily obtained.

4. That every fleet needs a repair ship to enable the efficiency to be maintained without leaving the station, and consequently that several ships should be equipped so as to be ready to proceed with the fleet.

5. The great tactical advantages of water-tube boilers. This has already been discussed under another head.

6. That if more than two main engines are to be fitted, there should be three engines driving three screws, and not two main engines on each shaft. The New York and Brooklyn had their forward engines disconnected at the time of the Santiago fight, and could not stop to couple them. An accident to any part of either of the two engines on a shaft disables half the power; in the three-screw ship this friction would be only a third.

7. That there should be frequent trials under forced draft to keep the blowers in good condition and to make the men thoroughly familiar with working under maximum conditions. It appears that some of the ships had never been under forced draft since their contract trials until the day of the fight at Santiago.

8. That the location of the forced-draft blowers is a matter of serious importance. In some of our ships, owing to the demands for all other space for other purposes, the blowers had to be located in corners or pockets in the fire rooms, where it was impossible for human beings to give them proper attention, owing to the intense heat due to lack of ventilation. In the Cincinnati temperatures as high as 205° Fahrenheit were noted, and the commanding officer, when investigating the case personally, had his face scorched. The blowers must be placed where they can be properly cared for, or else they are useless, and might as well be left on shore.

9. That the personnel of the service should be adequate to the material. It has been notorious for some time that this is not the case, and we are providing for a decided increase in the number of vessels with no increase whatever in the personnel. By sending nearly every officer on the active list to sea, we were able to give the regular ships a fair complement of trained ones, but had the war been of long duration we should have been greatly embarrassed to supply the places of those disabled or invalided. Volunteers, however well trained in other ways, cannot entirely replace the regular officer.

10. That we must make provision for training the enlisted men of the Engineer Department. Many of the colliers and auxiliary vessels had to start out with absolutely green crews, many of whom, so far from having the "sea habit," had never been on a vessel of any kind. This must be remedied if our enlarged fleet is to be efficient.

11. That our fighting ships must have the highest practicable speed. There is an almost general agreement on this point among naval men, but if any had thought that this did not apply to battleships the fight at Santiago must have shown that the highest practicable speed is just as important in these vessels. It is very gratifying, therefore, that our three new battleships are to have speeds of at least 18 knots, which is now recognized as the standard.

Receivers have been appointed for the Atlantic Transportation Co., which not long ago chartered a number of steamers and barges on the Great Lakes of the capacity of nearly 70,000 net tons, for the purpose of using them in the Atlantic coast trade, carrying coal chiefly. A complete list of these vessels and their owners was published in our November, 1898, issue. Since the charters were written it is stated the company has lost large sums of money through wrecks, though a considerable amount of insurance was carried on the vessels. In the application for receiver, which is made by Walter S. Besse on behalf of the company, the assets are stated to consist of twenty-four vessels, valued at $900,000 and worth at forced sale $613,000, and other sundry interests valued at $2,000; liabilities as figured out by Treasurer H. A. Harvey foot up about $1,000,000.

CORRESPONDENCE DEPARTMENT.

[Communications on matters of interest to marine engineers, for insertion in the correspondence department, are solicited. These, wherever possible, should be supplemented by rough sketches or drawings, which will be reproduced, if necessary to illustrate the subject, without cost to the writer.

Full names and addresses should be given, but publication of these will be withheld where requested.

We do not assume responsibility for the opinions expressed by correspondents.]

Efficiency of Naval Engineers.

Editor of Marine Engineering:

A correspondent who signs himself "Member Society S. N. A. & M. E." calls attention in a letter published in your January number to a statement credited to Lieutenant-Commander W. W. Kimball, U. S. N., and made at the late meeting of the Society of Naval Architects and Marine Engineers, as follows: "We have only very few officers of the Engineer Corps competent to give experienced trained engineering supervision to those repairs on torpedo boats which are attempted at Navy Yards, and those few are rarely available for the duty."

Your correspondent very properly states that if this be true the Engineer Corps should be "investigated" in the interest of the country at large. But it is, of course, not true, nor do I believe that Mr. Kimball ever intended to convey the idea which the words would seem to do.

The paper on "Torpedo Boat Utility," by Lieutenant-Commander Kimball, was, of course, read by me, and I noticed the phraseology referred to, but believed that what was intended to be said was that "We have only very few officers of the Engineer Corps to give the engineering supervision to repairs, etc., and those few are rarely available for duty." This construction brings us face to face with the fact that the Engineer Corps is much too small, and that of this small number there are very few who can be spared for duty on torpedo boats, or for shore duty at Navy Yards. This is undoubtedly the idea that Mr. Kimball meant to convey, as he is an officer of too much experience to believe for a moment that the Engineer Officers who superintend so successfully the repairs on our battleships and cruisers of various types are not competent to do similar work on torpedo boat machinery.

While in command of the torpedo flotilla Lieutenant-Commander Kimball appreciated the services of the one Engineer Officer who could be spared for duty with that little fleet, and he expressed his appreciation on more than one occasion.

George W. Melville,
Engineer-in-Chief, U. S. N.

An Effective Quick Repair.

An experience I had with makeshift repairs not long ago would, I believe, interest many of your readers. At the time I was third engineer in the frozen mutton trade, sailing from River Plate to Liverpool. We finished loading our cargo, having about 18,000 frozen carcases in the after part of the ship and a general cargo forward. Our refrigerating plant consisted of a large cold-air machine driven by a compound steam engine supplied with steam from the main boilers. I might add that the machine did its work well, though it was rather extravagant on steam.

We left Buenos Ayres and all went on smoothly until the tropics were reached, when one morning we heard a crash in the machine room and a stoppage of the engine. On examination we discovered that the crosshead of the compression engine had broken, as seen in sketch *A*. The crosshead and piston rod for this engine were in a solid forging, and we had no spare one on board. Our machine was completely disabled, as we were dependent on the compression, cooling and expansion of air for the efficiency of the machine. As we were in the tropics, whatever was done should be done quickly, as the temperature in the chambers would soon increase. So we took a spare crosshead bolt, flattened the head end like a palm stay and pinned it with two set screws to the piston rod, then coupled up and started the machine.

This arrangement only lasted about a quarter of an hour, when the bolt carried away at the weakened end. Then we decided to make a plate to pass over the piston rod, with holes for the crosshead bolts. We had no suitable iron in our engine room stores, so we took a small kedge anchor from the deck, cut a piece from it which was 4 in. thick, heated in the furnace fires and swaged it down to 2 3-4 in., which was the clearance between the heads of the bolts and the packing gland on the cylinder. Then we drilled three holes and had a plate something like the sketch *B*. Our spare crosshead bolts were too short, but fortunately we had spare ones belonging to the crank pin, which suited nicely. Making this plate with imperfect ship tools and drilling tackle took us considerable time and labor. Well, we put it in position, coupled all up and started the machine, which worked splendidly, and we thought our trouble for that voyage was ended.

About a week afterwards, when nearing the Cape De Verde Islands, we heard a peculiar knocking noise in the main engines, while the main bearing brass

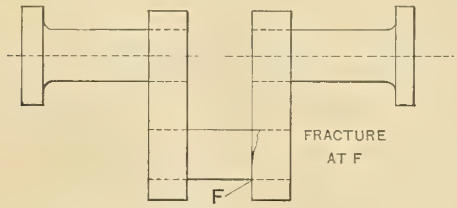


Fig. C.

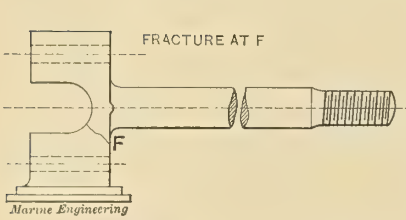


Fig. A.

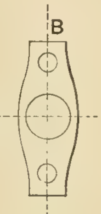


Fig. B.

next the after crank commenced to heat. We slowed down, and then noticed the webs of the after crank springing at each revolution. As the weather was squally, the skipper ran the ship under the lee of one of the islands and anchored for shelter. We then took off the crank pin brasses and found the crank pin broken just inside the web (Figure C). This was our after crank, but we had a spare crank that had been the forward one, and that had been taken out on account of a flaw. The chief engineer decided to fit it in the place of the broken one. We rigged blocks and tackle and let the tackle fall through the engine room skylight to a steam cargo winch on deck, disconnected the couplings and took out the shaft, which came away in halves. We then put in the spare one, and the couplings and bolts did not require very much fitting. We had to cut keyseats for the eccentric sheaves, which fitted on over the outside of the couplings. We did not waste much time fitting or scraping the crank pin and main bearing brasses, as we knew the shaft would require to be taken out again in Liverpool, so we coupled all up and proceeded under easy steam, after being stopped only twenty-eight hours—not a bad performance for four engineers and the ship's staff.

No other incident of note took place and we arrived in Liverpool safely and with our frozen meat in first class condition. W. T. Smith.

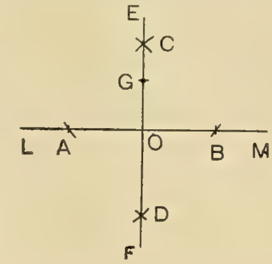
EDUCATIONAL DEPARTMENT.

CALCULATIONS FOR ENGINEERS—AN AID TO CANDIDATES FOR MARINE PAPERS—V.

BY DR. WILLIAM FREDERICK DURAND.

§ 10. PROBLEMS IN GEOMETRY.

[1] At any Point in a Straight Line to Erect a Perpendicular. Let O be the given point in the line $L\ M$. Then take points A and B such that $O\ A = O\ B$. From A and B as centers with any radius greater than $A\ O$ or $O\ B$, describe arcs cutting in C or D, or if pre-

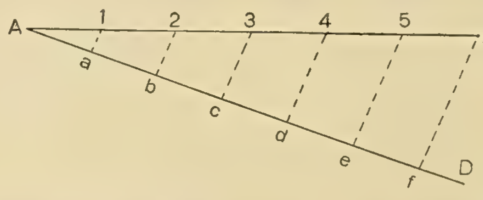


ferred, in both. Then a line drawn through O and C or O and D will be perpendicular to $L\ M$, or the line may be drawn through C and D, in which case it will also contain O and be perpendicular to $L\ M$ as before.

[2] To Bisect[10] the Distance Between Two Points. In the figure for problem [1] let A and B be the two points. Then finding points C and D as in [1] it is plain that the point O determined by drawing the line $C\ D$ will be the middle point between A and B as desired, and that we shall have $A\ O = O\ B$.

[3] To Find the Center from which to Pass an Arc of Given Radius Through Two Given Points. In the figure for problem [1] let A and B be the points. Then finding points C and D as in [1] it is plain that any point in the indefinite line $E\ F$ will be at equal distances from A and B. Hence from A or B as a center and with the given radius cut the line $E\ F$ in a point as G. This is the point desired.

[4] To Divide a Given Line Into a Given Number of Equal Parts. Let $A\ B$ denote the given line. Draw a line $A\ D$ at a small angle with $A\ B$, and lay off upon it as many equal divisions $A\ a$, $a\ b$, $b\ c$, etc., as it is desired $A\ B$ shall have. These divisions should be



so chosen that the total length $A\ f$ shall not widely differ from $A\ B$. Next draw $B\ f$ and then a series of parallels through the points of division $a\ b\ c$, etc. The points where these lines cut $A\ B$ will give the points of division desired.

[5] To Construct a Triangle, Having Given the Three Sides. Let $a\ b\ c$ denote the sides. Take $A\ B = c$, and from A as center and with b as radius, describe an arc $D\ E$, and similarly from B as center and with a as radius describe an arc $F\ G$. These arcs intersect in C, and drawing lines $A\ C$, $B\ C$, the construction is completed.

[10] To *bisect* a geometrical quantity means to divide it into two equal parts.

[6] To Bisect a Given Arc or Angle. Let $A\ O\ B$ denote the angle and $A\ B$ the arc. From A and B as centers, and with any radius greater than half the distance between A and B, describe arcs intersecting in

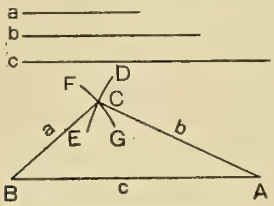


Figure for [5].

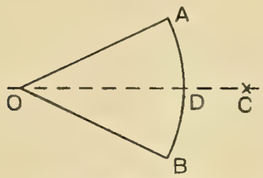
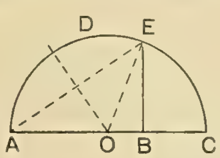


Figure for [6].

some point C. Then a line $O\ C$ will bisect the angle $A\ O\ B$ and at D the arc $A\ B$.

[7] To Construct a Mean Proportional[11] Between Two Given Lines. Let the two lines be denoted by $A\ B$ and $B\ C$ placed end to end. Find the



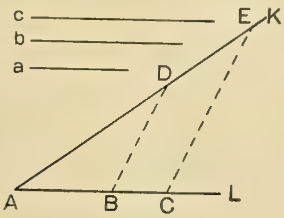
center O of the line $A\ C$, and describe a semi-circle $A\ D\ C$. Draw $B\ E$ at right angles to $A\ C$. Then $B\ E$ is the desired mean proportional, and we have:

$$A\,B : B\,E :: B\,E : B\,C$$
$$\text{or, } A\,B \times B\,C = B\,E^2$$

[8] To Construct a Fourth Proportional[12] to Three Given Lines. Let a, b and c denote the three lines, and let the desired proportion be:

$$a : b :: c : (\ \ )$$

Lay off $A\ B = a$ and $A\ C = b$. Then at any convenient



angle lay off $A\ K$ and take on it a distance $A\ D = c$. Draw $B\ D$ and $C\ E$ parallel to it. Then $A\ E$ is the fourth term desired and we have:

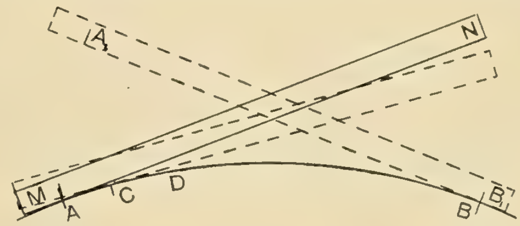
$$A\,B : A\,C :: A\,D : A\,E$$
$$\text{or, } A\,B \times A\,E = A\,C \cdot A\,D$$

[9] To Construct a Square Equivalent in Area to a Given Rectangle. Find by problem [7] a mean proportional between the sides of the rectangle, and this will be the side of the square desired.

[10] To Construct a Square Equivalent in Area to a Given Triangle. Find by problem [7] a mean proportional between the base and half the altitude, or between the altitude and half the base. This will be the side of the square desired.

[11] With One Given Side, to Construct a Rectangle Equivalent to a Square. This is equivalent in [7] to having given $A\ B$ the side of the rectangle and $B\ E$ the side of the square. Find by the use of the construction in problem [1] a point O on $A\ B$ at equal distances from A and E and describe the semi-circle. Then $B\ C$ is the remaining side of the rectangle desired.

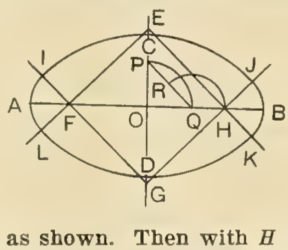
[12] To Find the Length of an Arc of a Curve. Let $A\ C\ D\ B$ denote the given arc. Take a strip of paper $M\ N$ and lay with an edge just neatly tangent to the curve at A. Mark a point opposite A on the strip. Then, placing the pencil at C, a point near where the curve and edge of the paper strip begin to separate, bear down slightly and rotate the paper about C as a center until the edge is tangent at C or at a point slightly beyond. Then move the pencil along



to a point D and repeat, and so on until the strip has been thus rolled along the curve to B. The distance $A_1\ B_1$, between the point opposite A on the strip at the start and the point opposite B at the end, will be very close to the true length of the curve. A little experience will enable the points $C\ D$, etc., to be so chosen that the error will be very small. A check on the operation may be obtained by reversing the process and rolling the paper back to the original position. If the point A_1 comes again to A it shows that no slip has been made, and the distance found may be accepted as a very close approximation to the true length of the curve.

[13] To Construct an Ellipse. Of the many methods available, three are given as follows:

(1) Given the two diameters $A\ B$ and $C\ D$. Take $B\ Q$ equal to $O\ C$ and then $O\ P$ equal to $O\ Q$. Draw $P\ Q$ and find R its middle point. Then take $Q\ H = Q\ R$, and $O\ E$, $O\ F$, $O\ G$ all equal to $O\ H$. Through E, F, G and



H draw lines as shown. Then with H and F as centers draw arcs $J\ K$ and $I\ L$, and with E and G as centers draw arcs $L\ K$ and $I\ J$. These arcs join and complete the contour. While this method is only approximate and does not give a true ellipse, it answers very

[11] A mean proportional between two quantities a and c is a third quantity b, such that we have:

$$a : b :: b : c$$
$$\text{or, } b^2 = a\,c$$
$$\text{or, } b = \sqrt{a\,c}.$$

See also § 6.

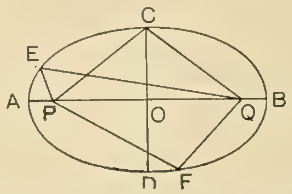
[12] A fourth proportional to three quantities a, b and c is a quantity d, such that we have:

$$a : b :: c : d.$$

See also § 6.

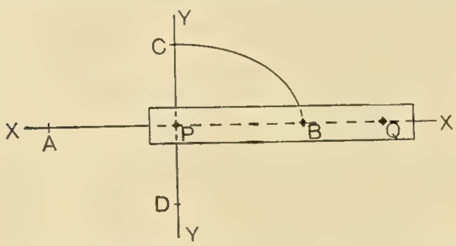
well for draughting purposes where a good representation of an ellipse is all that is desired.

(2) This method is exact in principle. Given $A\ B$ and $C\ D$ the two diameters as before. With C as center and $C\ Q = O\ B$ as a radius find the points P and Q. These are the *foci* of the ellipse. Then adjust a thread



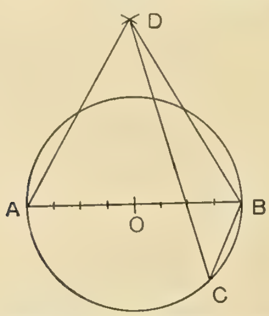
$P\ C\ Q$ secured at P and Q and of a length $P\ C + C\ Q = A\ B$. A pencil carried around in the bight of this thread, as shown in different positions at E, C, F, will trace the ellipse desired.

(3) This method is also exact in principle. Given $A\ B$ and $C\ D$ the two diameters as before. Prepare a strip of cardboard or thin wood with holes P, B, Q, such that $P\ B$ equals one-half $A\ B$ and $B\ Q$ equals one-



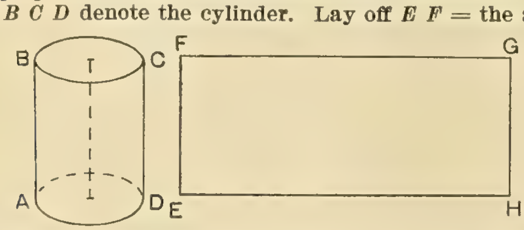
half $C\ D$. Then move the *trammel*, as it is called, so that P shall always move on the vertical $Y\ Y$ and Q on the horizontal $X\ X$. The point B will then trace the ellipse desired. If points on the curve only are required, this method is readily applied.

[14] To Construct any Regular Polygon (approximate). Let $A\ B$ denote any diameter of the given circle within which the polygon is to be inscribed. Divide $A\ B$ into as many parts as there are to be sides in the polygon. From A and B as centers and radius $A\ B$



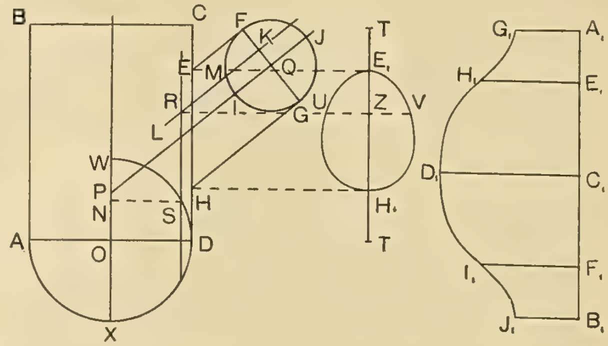
describe arcs cutting in D. From D draw a line $D\ C$ through the second of the points of division. Then $B\ C$ is the side of the polygon desired within a very small error. For the square or hexagon, or when the number of sides is 4 or 6, the construction is exact.

[15] To Develop the Surface of a Cylinder. Let $A\ B\ C\ D$ denote the cylinder. Lay off $E\ F$ = the altitude



tude and $E\ H$ = the circumference of the base, $= \pi \times$ diam. $= 3.1416 \times$ diam. Then the rectangle $E\ F\ G\ H$ represents the development desired.

[16] To Develop the Surface of a Cylinder Which is Intersected by Another Cylinder, the Two Axes Being in the Same Plane. The developed form of the intersection is the only part requiring special notice. Let $A\ B\ C\ D$ and $E\ F\ G\ H$ denote the two cylinders. Draw any line $T\ T$ to denote the element $C\ D$ in the developed surface of $A\ B\ C\ D$. Then the developed form of the intersection will be symmetrical about $T\ T$. Project E and H over to E_1 and H_1 for the top and bottom of the curve. Then to find intermediate points proceed as follows: Draw any line $K\ L$ parallel to $P\ Q$ and denoting the edge of a plane per-

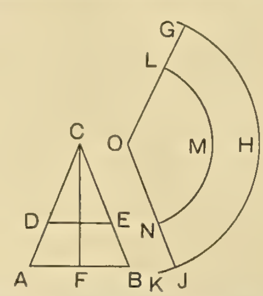


pendicular to the paper and cutting both cylinders. With $F\ G$ as diameter describe the circle as shown, and with $A\ D$ the semicircle $W\ D\ X$. Make $N\ O$ equal to $M\ K$ and project over to S, thence up to R and then over to $T\ T$. Rectify the arc $S\ D$ and lay off $Z\ U$ and $Z\ V$ each equal to the rectified length. Then will U and V be points on the curve as desired. Other points may be found in a similar manner and the curve filled in.

To develop the form of the smaller cylinder proceed as follows:

Let $C_1\ D_1$ denote in the development the element $H\ G$. Lay off $A_1\ B_1$ = the circumference $I\ F\ J\ G$. Then for the points corresponding to the plane $K\ L$ take $C_1\ E_1 = C_1\ F_1$ = the developed length of the arc $G\ M$. Then draw $E_1\ H_1$ and $F_1\ I_1$ each equal to $K\ R$. This will give two points, H_1 and I_1, and others may be found similarly and the curve filled in as shown.

[17] To Develop the Surface of a Cone. Let $A\ B\ C$ denote the cone. With $A\ C$ as radius and any point O as center, draw an arc, $G\ H\ K$. Then lay off

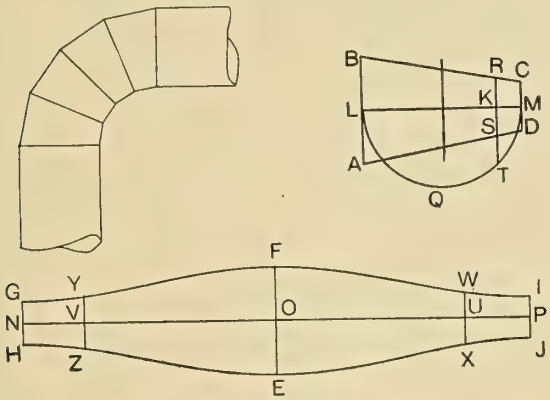


the circumference of the base $A\ B$ ($= 3.1416 \times A\ B$) on a strip of paper, and lay off this length by rolling as in problem [12] from G to some point J. Then the arc $G\ H\ I$ = circumference of $A\ B$ and the sector $O\ G\ H\ J$ is the developed surface of the cone.

[18] To Develop the Surface of the Frustum of a Cone. Referring to the figure for the preceding problem, let $A\ D\ E\ B$ denote the frustum. Then, after proceeding as in that problem, take next a radius $O\ L = C\ D$ and describe the arc $L\ M\ N$. Then will the sector $O\ L\ M\ N$ represent the surface of the cone

C D E, while the strip *L G H J N M* represents that of the frustum.

[19] To Develop the Segments of an Elbow. These are portions of a cylinder cut by oblique planes. Let *A B C D* denote such a segment. Draw *L M* perpendicular to *A B* and construct the semicircle *L Q M*. *L M* may be placed at any convenient location between *B C* and *A D*. In the development let *E F* denote the element *A B*. Make *F O* = *B L* and then draw perpendicular to *E F* lines *N O* = *O P* = each to the semicircumference *L Q M*. Then *N P* is the development of



L M. Lay off *N G* = *P I* = *M C* as shown. Then to find intermediate points on *G F I* take any line *R S* and project down to *T*. Develop *L Q T* and lay off the developed length at *O U* and *O V*. Then make *V Y* and *U W* each equal to *K R*, and *Y* and *W* will be points on the development of *B C*. Other points may be found in a similar manner and the development of *B C* completed as shown by the curve *G F I*. The curve *H E J* as the development of *A D* may be found in an entirely similar manner, and if *B C* and *A D* are equally inclined to the elements of the cylinder, *L M* will naturally be located midway between them, and *H E J* will be symmetrical with *G F I* about *N P*, and both may thus be found at the same time by laying off above and below *N P* the distances determined as above shown.

§ 11. PHYSICS.

[1] Acceleration Due to Gravity. In engineering computations there frequently enters a quantity known as the *acceleration of gravity* or the *acceleration due to gravity*, and denoted by the symbol *g*. This is the change per second which the gravity or attraction of the earth is able to bring about in a freely falling body. For engineering purposes its value is usually taken at 32.16 or 32.2.

[2] Specific Gravity. The specific gravity of a given substance is the relation between the weights of equal volumes of the given substance, and of some standard substance, usually water. Thus a specific gravity of 8 means that, volume for volume, the given substance is 8 times as heavy as water.

[3] Heat Unit. Heat is measured in terms of a unit defined as the amount of heat required to raise 1 lb. of water 1 deg. in temperature at 60 deg. Fahrenheit, or from 60 deg. to 61 deg.

[4] Specific Heat. The specific heat of a substance is the relation between the amount of heat required to raise it 1 deg. at the given temperature and under given conditions as to pressure or volume, and the unit of heat as just defined. Thus a specific heat of .32 means that under the given conditions it will require, to raise the temperature 1 deg., .32 of the heat necessary to raise 1 lb. of water from 60 deg. to 61 deg.

[5] Expansion of Metals. Nearly all substances expand with the addition of heat, and usually with nearly equal amounts per degree rise of temperature, especially where the substance is not near its melting or boiling point. The following table gives the *coefficient of linear* or *length expansion* for various substances. This is the expansion in unit length for 1 deg. Fahr. rise of temperature.

Substance.	Coef.	Substance.	Coef.
Aluminum	.0000123	Iron, cast	.0000056
Brass, cast	.0000096	Iron, wrought	.0000065
Brass, drawn	.0000105	Lead	.0000157
Brick	.0000031	Mercury	.0000333
Bronze	.0000099	Steel, cast	.0000064
Bismuth	.0000098	Steel, wrought	.0000069
Concrete	.0000080	Tin	.0000116
Copper	.0000089	Zinc	.0000141
Glass	.0000045		

To find the expansion in the length of any bar for any given rise in temperature we have the following:

Rule—Multiply the coefficient taken from the table by the number of degrees, and this by the length of the bar, and the product is the expansion desired.

Example: What is the expansion of a steel bar 20 ft. long between 60 deg. and 350 deg. Fahr.?

Ans.: $.0000069 \times 290 \times 20 = .04$ ft. = .48 in.

The coefficient for area or surface expansion is taken twice that for linear expansion, and that for cubic or volume expansion is taken three times that for linear expansion.

Example: What is the increase in area between 60 deg. and 300 deg. Fahr. in a copper sheet having an area of 54 sq. ft.?

Ans.: $.0000178 \times 240 \times 54 = .231$ sq. ft. = 33.3 sq. in.

What is the increase in volume between 100 deg. and 200 deg. Fahr. in a piece of brass having a volume of 2 1-2 cu. ft.?

Ans.: $.0000288 \times 100 \times 2.5 = .0072$ cu. ft. = 12.44 cu. in.

§ 12. MECHANICS.

[1] It is a general law of nature that all bodies tend to remain unchanged as regards their condition of rest or relative motion. A body at rest does not move unless caused to do so by some outside agency. A body in motion continues to move until it is brought to rest by outside agencies such as friction, resistance of the air, or of water, etc.

[2] Force. Any agency which changes or tends to change the condition of a body as regards its rest or relative motion is called a *force*. For engineering purposes force is measured by the *pound* or *ton* as unit. In marine engineering the ton, unless otherwise stated, is usually of 2,240 lb.

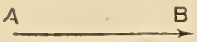
[3] Specification of a Force. A force has three characteristics or particulars:

(1) Its line of direction, as north and south.
(2) The way it acts in that line, as north.
(3) Its magnitude.

A force may therefore be completely represented by a line *A B* of length to represent the magnitude, and

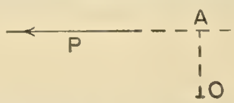
drawn in the direction of the line of action of the force.

Thus the force *A B* would mean a force represented in amount according to some scale by the length *A B*, and acting along the line *A B from A to B*. The direction of action is also frequently denoted by an arrow point, thus:



[4] Moment of a Force. This is the product of the magnitude or measure of the force multiplied by the perpendicular distance from its line of action to a given reference point.

Thus in the figure let the full line represent a force, *P* denote its measure, and *O* the reference point. Then



$P \times O\ A$ is the moment of the force *P* about the point *O*. In the term *moment of a force* a point of reference is therefore always implied.

[5] Resultant. The resultant of a system of forces two or more in number with their lines of action all meeting at a common point, is the single force which represents the combined action or result of the system.

[6] Work. Work is done when a force (or resistance, as it may be called in such case) is overcome; as for example when a weight is lifted or a ship is forced through the water. Work is measured by the product of the resistance by the distance through which it is overcome. The two essential factors of work are therefore *force* or *resistance* on the one hand, and *motion* or *distance* on the other. The unit of work is the *foot pound* or the work done in raising one pound weight one foot in height. Thus if 16 lb. be lifted 20 ft. the work done is $20 \times 16 = 320$ ft. lb.

[7] Power. Work in itself is independent of the time required to do it, and depends simply on *resistance* and *distance*. Power means a certain amount of work performed in a given time. The common unit is the *horse-power*, which is 33,000 ft. lb. of work performed in one minute. The added element involved in power should not be forgotten. Thus 33,000 ft. lb. of work performed in 1 hour would not mean one horse power, but only $\frac{1}{60}$ of such amount, while 33,000 ft. lb. of work performed in 1 second would mean 60 horse power. Likewise 550 ft. lb. per second represents one horse power as also 1,980,000 ft. lb. per hour. To find the horse power in any given case we have therefore the following:

Rule—Find the foot pounds of work performed per minute and divide by 33,000.

Example: An engine in one-half hour performs 118,800,000 ft. lb. work. What is the horse power?

$$\text{Horse power} = \frac{118,800,000}{30 \times 33,00} = 120$$

[8] Energy. This is the capacity for performing work, and depends on special conditions of motion or location. For convenience energy is considered of two kinds.

Kinetic Energy is the energy possessed by a body in virtue of a condition of motion. As we know, such a body resists an attempt to stop it, and it will overcome a certain resistance through a certain distance before being brought finally to rest. This kind of energy is measured by the formula $E = \frac{W v^2}{2 g}$ where *W* is the weight in pounds, *v* is the velocity in feet per second, and *g* is the acceleration due to gravity or 32.2. Since energy is directly convertible into work it must be really similar in character to work, and we may therefore speak of so many foot pounds of energy, just as well as of so many foot pounds of work.

Potential Energy is the energy possessed by a body in virtue of its location or condition relative to the forces acting on it. Thus a weight lifted to the top of a building has potential energy relative to the street because it could do work if allowed to move downward. Similarly a compressed spring or a compressed gas has potential energy because either, if properly allowed to return to the condition toward which it tends, will perform work. Potential energy is measured by the work which could be thus performed, or by its equal the work which must be done upon the body in order to produce the given condition; as for example the work done in lifting the weight to the top of the building, or in compressing the spring or gas. Potential energy is therefore measured directly in foot pounds.

[9] Conservation of Energy. It is a fact of universal experience that energy can neither be destroyed nor created. If it seems to disappear or to appear, it is but apparent, and the result simply of a change of form. Energy may exist in a variety of forms, as (1) Mechanical, (2) Thermal, (3) Electrical, (4) Chemical, and *when there is an increase in any one form there must be an equal decrease in one or more of the other forms*, and likewise *when there is a decrease in any one form there must be an equal increase in one or more of the other forms.* There may be a like exchange between kinetic and potential energy, the one increasing as the other decreases, and *vice versa.* Thus with mechanical energy if there is no change to other forms we shall find that the sum of the kinetic and potential energies is always the same, and that one increases as the other decreases and *vice versa.* In this view work simply appears as an attendant upon the exchange of energy, or more definitely, as a measure of the exchange. Again if we fix our attention upon one body, its changes of total energy measure the work which it receives or gives out. If its energy increases it has had work done upon it. If its energy decreases it has given out work to some other body.

[10] Statics. If the forces which act on a body are properly related or balanced, the body remains at rest. The conditions necessary to the realization of this state of rest under the action of forces form the subject of *statics.*

[11] Dynamics. If the forces are not so related, the body does not remain at rest and motion results. The amount and nature of such motion and its relation to the system of forces form the subject of *dynamics.*

Chief Engineer Walter M. McFarland, U.S.N., has obtained a six months' leave of absence and associated himself with the Westinghouse Electric and Mfg. Co., at Pittsburg, Pa., where he will hold the important position of Assistant General Manager. His resignation from the Navy is to take effect at the end of his leave of absence. At the time of his leaving the Naval service Mr. McFarland was assistant to Engineer-in-Chief George W. Melville and was also prominently identified with the splendid *Journal of the American Society of Naval Engineers.* Mr. McFarland is widely known in engineering circles at home and abroad: he not long ago was appointed to represent the United States Navy at the International Congress of Naval Architects and Marine Engineers in London. We understand that in his new position he will receive a salary very much larger than that which he could hope to draw from the Government service. He carries with him to his new sphere of action the sincere good wishes of his naval associates and those outside of the Department who have known him as an estimable gentleman and an engineer of great ability.

HELPS FOR CANDIDATES FOR MARINE ENGINEERS' LICENSES—FUELS—II.

BY DR. WILLIAM FREDERICK DURAND.

[5] SPONTANEOUS COMBUSTION. We have already seen under the head of *weathering* that coal at ordinary temperatures is subject to a very slow oxidation, or combustion, which gradually wastes away its fuel value. Also that a necessary consequence of this is the slow development of heat. Now, if the coal is in small bulk and well ventilated, there will be little chance for the gradual accumulation of the heat and a consequent rise of temperature. A few lumps of coal exposed to the open air may lose much by weathering in the course of six months or a year, but the heat set free will readily escape and the rise of temperature will be unnoticeable. If, on the contrary, the coal is in large bulk, or is confined in bunkers with little or no ventilation, the heat developed by slow oxidation will be imprisoned and the temperature may gradually rise to the point where active combustion will proceed according to the supply of air available. In such case, however, the limited supply of air tends to limit the progress of the combustion, and it might therefore at first sight seem a question which arrangement of the two would be better—good ventilation with a copious supply of air and consequently a low temperature, or poor ventilation with rising temperature, but with a limited supply of air for the support of the oxidation. General experience indicates that good ventilation provides much the safer arrangement of the two; that is, it is considered safer to provide plenty of air and keep the temperature down rather than to limit the supply and at the same time imprison the heat developed by what air may be available. Since, also, as explained in [4], the hydrocarbons are more subject to this slow combustion than carbon alone, it is clear that the danger of spontaneous combustion will be much greater with bituminous than with anthracite coal. In fact the latter variety of coal may be considered as beyond the danger of spontaneous combustion under all ordinary circumstances. On the other hand, only too many cases of spontaneous combustion with different varieties of bituminous coal are on record.

The general conditions favorable to spontaneous combustion are the following: A large mass or bulk of coal, confinement or poor ventilation, high temperature, and a quality of coal rich in the lighter and more readily oxidized hydrocarbons.

Iron pyrites has sometimes been thought a possible cause of spontaneous combustion, but the proportion of this substance is usually small, rarely rising above four or five per cent, and the heat developed by the combustion of sulphur and iron is also much less per pound than for carbon and hydrogen. The heat developed by the oxidation of iron pyrites is therefore hardly sufficient to do more than help along the general condition of slow combustion, which, with light hydrocarbons and other favorable conditions, may result in spontaneous active combustion. The fact that cases of spontaneous combustion are more commonly met with in coal especially rich in light hydrocarbons rather than in that having a high percentage of iron pyrites, also shows that the former rather than the latter is to be considered as the responsible cause.

The gases imprisoned within the coal, reference to which was made in [4], may also escape and collect in a closed and unventilated compartment or bunker, and upon the later introduction of a light an explosion may result. This is exactly similar to the way in which firedamp explosions in mines may result. Thorough ventilation of such bunkers or spaces is the safeguard against such danger, and it should not be neglected, especially with coal of a quality likely to freely disengage such gases.

[6] CORROSION. As a further possible result of the presence of iron pyrites and the sulphur which is one of its constituents, the corrosion of the metal surfaces of the boiler may be mentioned. Sulphur in burning in the presence of moisture may produce sulphuric acid, and this may seriously corrode such surfaces as it comes in contact with, especially if there is opportunity for its gradual action during periods when the boiler is not in active use. The conditions necessary for the formation of sulphuric acid are, however, not commonly present in marine boilers, and the danger of corrosion from the combustion of iron pyrites is not usually considered as serious.

[7] TRANSPORTATION AND STOWAGE. In general anthracite coal bears transportation and handling better than bituminous on account of its greater hardness. It also stows more evenly on account of the greater uniformity in size of lump.

The weight of coal in the solid lump is from 70 to 80 lb. per cubic foot for bituminous grades, and from 85 or 90 to 100 lb. per cubic foot for anthracite grades. When broken up in ordinary commercial sizes, however, its weight in bulk is usually from 50 to 54 lb. per cubic foot for bituminous, and from 53 to 58 lb. per cubic foot for anthracite. These weights correspond to an allowance of from 42 to 45 cu. ft. per ton of 2,240 lb. for bituminous grades and from 39 to 42 cu. ft. per ton for anthracite grades.

[8] GENERAL COMPARISON BETWEEN BITUMINOUS AND ANTHRACITE COAL. As between the two kinds of coal, bituminous burns more readily than anthracite, and requires a somewhat lower temperature for the process. This is because with the former the hydrocarbon gases are first driven off and burnt, while the coke residue is left in a light and porous condition, and thus well suited for intimate contact with the oxygen, and for rapid elevation to the temperature of ignition. On the other hand, with anthracite coal the hydrocarbon gases are so small in amount as to have little influence on the process, and the coal has therefore to burn as compact, solid lumps of carbon, with little opportunity for contact with the oxygen except at the outer surface.

It results that under the same conditions of draft, firing, etc., considerably more coal can be burned per square foot of grate surface with bituminous than with anthracite. The excess of the former will depend, of course, on the special conditions, but will usually reach from 20 per cent to 40 per cent, or even more.

From the explanation given in [2] it will be clearly seen that smoke and soot are chiefly the products of bituminous coal. With anthracite coal, immediately after firing, a slight show of smoke may be formed, but with neither the volume nor density of the smoke formed by bituminous coal, while the soot formed with anthracite is too small in quantity to be of any significance.

Bituminous coal, as we have seen, is more liable to spontaneous combustion than anthracite, and the loss by weathering is usually more serious.

A good quality of free-burning semi-bituminous coal is usually considered as the best variety for all around steaming purposes.

§ 2. BRIQUETTES AND ARTIFICIAL FUEL.

This fuel is made from small bits of coal, coal dust, or from certain grades of coal which are so soft or crumbling that they cannot be readily used in their natural state. The material after selection and removal of impurities, so far as practicable, is reduced to powder by grinding, and is then mixed with some binding material and pressed into cubes or blocks weighing from one to three or four pounds each. The binding material is usually coal-tar, asphalt, crude oil refuse, or some similar substance. In some cases a caking coal has been used by heating until softening occurs and then pressing into moulds while hot.

The character of such fuels will of course depend on the nature of the materials of which they are made. By a proper choice of the ingredients or by a suitable enriching with hydrocarbons in the form of pitch or crude oil, a fuel of most excellent quality may be made. The pressure to which the blocks are subjected is so great that the materials become closely compacted together and hold their form with no more breakage through handling than with a good quality of semi-bituminous or even semi-anthracite coal. The best grades of artificial fuel ring when struck and absorb little or no water, thus showing a compact and firm structure throughout. They ignite readily and burn freely without an excessive formation of smoke, holding their shape without crumbling too rapidly on the grate. In evaporative power the best briquettes are the equivalent of good coal, from which indeed they differ chemically in no essential character.

The weight per cubic foot and the number of cubic feet per ton when stowed loosely are about the same as for good semi-bituminous coal of like quality. If packed regularly the waste space is much decreased and the cubic feet per ton will be reduced to from 25 to 35.

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§ 3. LIQUID FUEL.

[1] Composition. The only liquid fuel of importance to the engineer is either crude petroleum oil, or the residue left after removing from the crude oil by distillation the lighter constituents, consisting of naphtha, illuminating oil, etc. Crude petroleum oil is a liquid of brownish tint varying from light straw almost to black. It consists of a very complex mixture of many hydrocarbons. Some of these vaporize very easily and escape rapidly, even at ordinary temperatures. Such constitute the naphthas and gasoline. Next in order come the constituents which form common illuminating oil or kerosene. Then still heavier and denser come the lubricating oils of various kinds. After the removal of these there still remains a residue capable of yielding paraffine and vaseline, and last of all a certain amount of gas tar and coke.

When the process of refining or distillation is arrested after the removal of the naphthas and illuminating oils and perhaps some of the lubricating oils, the residue consists of a rather thick viscid liquid, not readily ignited as compared with the crude oil, but under proper conditions burning readily and with great heating power. Such residue in the Russian oil wells on the Caspian is called *astatki.* It constitutes more than one-half of the crude oil. On the other hand, with American oils the similar residue is much less in amount, rarely rising to one-third of the crude oil. Furthermore the processes of refining are so much superior in the United States that of final residue after the removal of all marketable products, there is almost nothing left. With the best modern methods of treatment, therefore, the use of the residue after partial refinement does not mean the utilization of a waste or by-product, but the use of a substance having a definite market value for other and long established uses. For the direct use of crude oil the same is true in still higher degree, so that under modern conditions the use of liquid fuel means simply a competition with the various other industries involving the use of the various products of crude petroleum oil.

[2] Combustion. For the combustion of crude oil or liquid refuse, the chief essential is that it must be "pulverized" or "atomized"—that is, broken up into a very fine spray and thus brought into intimate contact with the oxygen of the air. This is accomplished by special devices fitted to the furnace and called "pulverizers" or "atomizers." They are of two chief varieties according to the means used—either compressed air or steam. In each the oil is fed by pump or allowed to flow by gravity to the nozzle of the device. Here it is caught by a jet of air or steam, as the case may be, issuing near or through it, and by this means is thoroughly broken into a fine spray and blown into the furnace in this condition. Once the fire started, the spray is ignited as it issues from the nozzle so that the result is a long, fiercely burning jet of flame directed into the furnace. In order to produce the conditions best for complete combustion, it is usually found advantageous to have fire brick so disposed as to take the direct action of the flame. These bricks become heated to a high temperature and by their radiating action help to produce and maintain a temperature suitable for the complete combustion of all gaseous products formed from the liquid spray.

Under proper conditions oil may thus be burned with little or no formation of smoke or soot. The absence of all soot is especially favorable to the maintenance of a high efficiency of operation. There is furthermore no clinker or ash, no cleaning of fires, no opening of furnace doors either for firing or cleaning, and no handling of ashes.

[3] Danger of Explosion. The danger of explosion or of the formation of an explosive mixture by the slow distillation of the lighter hydrocarbons is considerable with crude oil unless due attention is given to the airing and ventilation of the spaces where such gases can collect. So long as the spaces containing oil are full there is no danger of any such trouble, but when they are partially empty the gases may collect in the vacant parts, forming with the air an explosive mixture which needs only a spark or other source of fire to explode with violence. Crude oil residue does not contain these lighter substances and is therefore safe from danger of this character, though in all cases a due attention to the matter of ventilation may be recommended. It may also be noted that the more dangerous parts of the oil evaporate with readiness under ordinary temperatures, and that crude oil exposed to the open air rapidly loses these constituents and becomes thereby the safer for use. This operation corresponds to the *weathering* of coal, and entails of course some loss, but a loss the more permissible as it makes the fuel the safer to use.

[4] Evaporative Power. Liquid fuel has a much higher evaporative power pound for pound than coal. According to chemical analysis the combustion of one pound of liquid fuel should liberate from 20,000 to 22,000 heat units, or about one and one-half times as much as good coal. This, combined with better efficiency of operation than with coal, have given experimental results showing an evaporative power twice that of coal or even higher. A ratio of 1.7 : 1 or 1.6 : 1, however, is more commonly considered as representing the average relation under ordinary conditions, though in some cases the advantage has been still less marked.

[5] Stowage and Handling. The best oil residue is of about the same density as sea water or slightly heavier. It will thus run from 34 to 35 cu. ft. per ton. While therefore its specific gravity is less than that of a lump of coal, it stows much better, so that a given space is capable of holding from 15 to 20 per cent more fuel in the shape of oil than in the shape of coal. Combining this advantage with that in evaporative power per pound, it follows that the final result is to very nearly double the capacity for steam generation per cubic foot of space occupied by fuel. As a further point it may be mentioned that oil or liquid fuel may be stowed in many places on board ship not available for coal or for cargo in general. Such are ballast tanks, double bottoms, etc. Again, the ease with which oil may be handled, flowing as it does by gravity and stowing itself, is a further point in its favor. With proper facilities a ship may be provided with oil much more rapidly than with coal. It should be added,

however, that oil refuse at a low temperature may become quite stiff, flowing only sluggishly, especially in small pipes. This condition may require the provision of special means for heating the oil so as to insure the necessary degree of fluidity. Oil refuse is therefore not a fuel suitable for arctic exploration.

A further advantage for liquid fuel lies in the great reduction in the fireroom force which is possible with its use. The handling and firing being practically automatic, only a few men are required to look after the oil tanks and supply pipes in a general way, and one fireman can give to a large number of furnaces the slight general attention which they require. The chief work in the fireroom is therefore reduced to water tending, which remains as with coal.

[6] Use of Oil and Coal Combined. In some cases the use of oil in conjunction with coal has given promise of good results, especially on war ships, where it may be of the utmost importance to be able to very rapidly increase the power developed. In such cases the coal would be used alone under ordinary conditions, and oil added when the increase of power is desired. Experiments in the Italian Navy show that for the most complete combustion and best efficiency the proportion of oil to coal should be about one of oil to five of coal. In the same manner as above described the oil is pulverized and blown as a spray into the furnaces, where it burns with the gases given off by the coal. In this way the oil furnishes a powerful resource for suddenly forcing the fires and increasing the I. H. P. developed while the amount of oil carried or consumed is quite small compared with the supply necessary if oil were the only fuel used.

[7] Cost. The great drawback regarding oil fuel, and one that is apparently too serious to be overcome, is that relating to its price. At ordinary figures a pound of steam would now cost at least as much if generated by means of oil as by means of coal, and if the use of oil were undertaken by several large steamship companies or other large consumers, its price would rise to a point impossible at present to foresee. The use of liquid fuel is quite within the reach of present engineering means, and may be considered as a mechanical success. Due however to the limited supply, and to the uncertainties regarding its price, its use will probably, under present conditions, be quite limited as a fuel for the generation of steam.

The British Admiralty Court has decided that the French line steamship La Bourgogne was altogether responsible for the collision with the British ship Cromartyshire, on July 4 last, near Sable Island, which resulted in the loss of the steamship and 550 lives. The Court held that the speed of the La Bourgogne at the time of the collision was excessive, considering all the circumstances, and that the Cromartyshire did everything possible to avert the collision. A number of damage suits are now pending against the French company, brought by the heirs of persons lost in the collision. Complete report of the mishap was published in our August, 1898, issue.

In a new form *The Nautical Gazette*, formerly and for a number of years known as *Seaboard*, the New York weekly publication, comes to hand. Instead of a sheet about 12 in. by 16 in., it is now issued in the convenient form, 8 in. by 11 in., and has an attractive cover. The character of the paper has been changed so that the political discussions with which it had long been identified are replaced by practical newsy and technical articles of general interest to those engaged in marine affairs. The management is now exclusively in the hands of W. H. and S. W. Stanton, the former partner, Alexander Smith, having retired to accept a state office. It is an old established journal and we wish it much prosperity in its new form and under its enterprising management.

ENGINEERS' DICTIONARY—XIV.

Excentric.—In general anything which is not truly centered or properly lined up with reference to some axis of rotation, or line of motion.

In particular an excentric is a circular disk, as in Fig. 51, attached out of center to the shaft of an engine. From the excentric by means of the excentric strap and rod is derived the motion for the valve which regulates the admission and exhaust of steam into and from the cylinder. The motion given by the excentric is exactly the same as that which would result from a crank of a throw equal to the distance from the center of the excentric to the center of the shaft. This distance is therefore called the *throw* of the excentric, although in some cases this term is used to signify twice this distance, or the whole distance traveled by the valve.

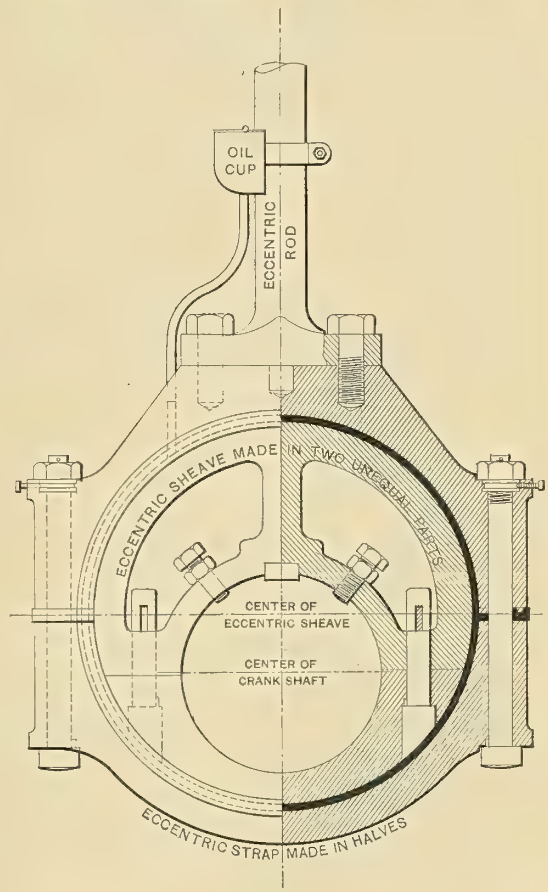


Fig. 51.

Excentrics are usually of cast iron or occasionally of cast steel, made in two parts, bolted together, and keyed in place on the shaft. The excentric shown in Fig. 51 is designed for a large marine engine. As shown, the excentric sheave is made in two unequal parts which come together at the diameter of the crank shaft so that the excentric can be readily fitted in place or removed without moving the heavy crank shaft. The faces where the two portions of the sheave join are tongued and grooved, making practically a solid sheave when bolted together. The heavy black lines show metal liners to take up wear.

Excentric Rod.—The rod, Fig. 51, by means of which the motion of the excentric is communicated to the link, and thence to the valve.

Excentric Rod Fork.—A forked or U shaped upper end usually given to the excentric rod, to facilitate its attachment to the link, Fig. 52.

Excentric Sheave.—The same as excentric above.

Excentric Strap.—The ring of metal which surrounds the excentric and forms with it the turning pair. The excentric in its motion around with the shaft turns within the strap and at the same time carries it to and fro. This latter motion is then, by means of the excentric rod and link, transmitted to the valve as already noted. Excentric straps are made in halves and bolted together. The material used is usually cast steel or bronze, and the inner surface is lined with white metal to give a bearing surface on the excentric. Brass or bronze may also be used as a liner for cast steel straps, while the white metal is sometimes omitted when the straps are of bronze. See Fig. 51.

Effective Horse Power.—The resistance which a ship would present if she were towed through the water at the given speed is called the *true* resistance. The work necessary to overcome this true resistance is called the effective horse power and is commonly

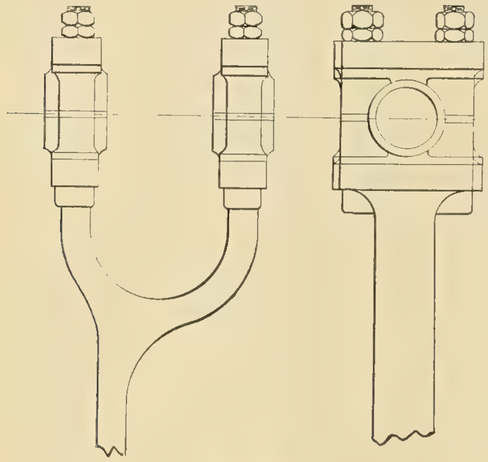


Fig. 52.

denoted by the initials E. H. P. It is only a fraction of the total indicated horse power, the remaining part having been expended in the friction of the engine and in the necessary work done on the water in obtaining the required propulsive thrust. The fraction usually realized is from 50 per cent to 60 per cent. This ratio is called the *propulsive coefficient.*

Effective Pressure.—In a steam engine cylinder there is always pressure on both sides of the piston. The effective pressure is the difference of these, or the net pressure acting in any one direction. Thus for example a pair of indicator cards may show at a given point in the stroke in the H. P. cylinder, say, that the pressure on top of the piston was 155 lb. per square inch while that on the under side was 90 lb. The effective pressure was therefore 65 lb. per square inch downward.

Efficiency.—This term always means a ratio of *returns* to *expenses.* Thus in a boiler the efficiency is the ratio of the heat transferred into the water to the total heat in the coal thrown through the furnace doors. The latter is the expense, the former the return. In the engine the expense is to be considered as the heat in the steam which is used, while the return is the indicated horse power developed. The efficiency is the ratio of the latter to the former. If we consider the return as the power delivered to the propeller, thus including the loss due to friction, then the efficiency of the engine becomes correspondingly less. In a propeller the expense is the work delivered to it from the shaft. The return is the work done by means of the thrust developed. The efficiency is the ratio of the latter to the former.

Ejector.—See **Bilge Ejector.**

Escape Pipe.—A pipe through which steam or water which has escaped through a safety or relief valve is led to a proper point for discharge. Thus on many steamers the main escape pipe leads from the main boiler safety valves up alongside the funnel to a suitable height for the convenient discharge of the steam.

Escape Valve.—A form of safety valve allowing the escape of steam or water when the load becomes greater than that for which the valve is set. On steam cylinders they are more commonly known as *relief* valves, and are made as in Fig. 53.

Evaporation.—A term referring in general to the change of water from liquid into steam. The word is also used in reference to the amount of water evapo-

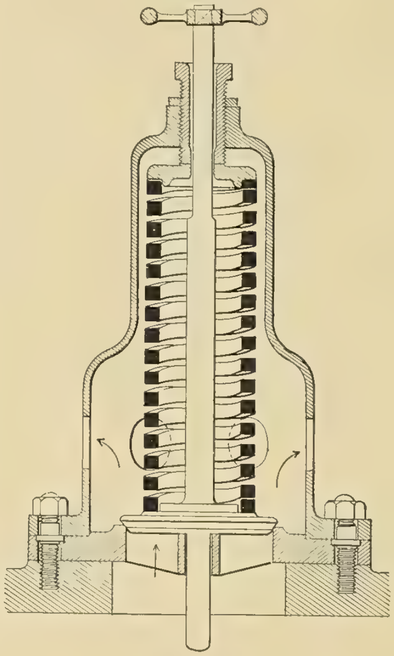


Fig. 53.

rated in the boiler per pound of coal burned on the grate. With hard forced draft, coal of poor or moderate quality, and poor firing, the *evaporation* may be no more than 7 lb. or even less. Under favorable circumstances with efficient combustion and good coal the *evaporation* may rise to 10 or 11 lb. or slightly over. Values of from 9 to 10 lb. are representative of good average conditions.

The arrival of the battleships Oregon and Iowa and the supply ship Celtic at Rio Janeiro in November was made the occasion of a hearty demonstration on the part of the English speaking colony there, which was participated in by the crews of the British warships Flora and Beagle, on that station.

The revenue cutter McCulloch, Captain Hooper, arrived at San Francisco January 10 after a voyage from Manila. Our regular readers will recall that an extensive description of this vessel was published in our June, 1897, issue. She was built for service in the Behring Sea and was on her way out, via the Suez Canal, when the Spanish war broke out. She was then impressed into the naval service and joined Admiral Dewey's fleet at Singapore, accompanying the fleet to Manila before the battle of Cavite. Her commander reports that on her voyage home she behaved admirably in rough weather, maintaining a speed of about 12 knots.

THE ART OF MAKING MECHANICAL SKETCHES —FOR MARINE ENGINEERS—VI.

BY PROF. C. W. MAC CORD.

What precedes has been mainly a brief explanation of the methods and principles of orthographic projection as used in the construction of mechanical drawings. These apply equally well to the making of working sketches; it has been remarked that a sketch is (in many cases at least) simply a rough drawing, made possibly without the use of instruments, but at any rate made so as to resemble an accurate working drawing as nearly as may be; so that some knowledge of the theory is necessary in order to make such sketches intelligently and rapidly.

Clearly, a sketch should contain all the data required for the reproduction of the object represented, and should convey its information in the most direct manner, with the least possible labor. It is therefore important to decide at the outset just what views are best adapted to this end, and to make those and no more.

Take for example the crank and part of shaft shown in Fig. 28; a glance at this figure shows that by its aid the pieces could be made, and that with no chance of error; the side view and end view are absolutely necessary, while a top view would be utterly useless. Rough and rude as the lines are, this sketch, with the aid of the dimensions given, would serve the mechanics' purpose as well as a careful instrumental drawing, because it contains precisely the same lines and figures which would be found in such a drawing.

Now, supposing these parts to be given, he who is to make the sketch must be provided with a large pair of calipers and a folding rule (or if great accuracy is required, with a steel scale), for making the measurements. Also with pencil and paper, and if time be an object, with a pair of pencil compasses.

In the latter case, the most expeditious process is to draw first the center lines *A B*, *C D*, *E F*, using the scale as a ruler; next with the compasses to draw the circles of the shaft and the crank pin and their hubs; and finally to make the outlines of the side view also by the aid of the ruler, using the compasses too, to fix the diameter of the hubs, the shaft and the pin. All this, in the case of so simple a subject, even the beginner can do without any outrageous disproportion, even if no measurements be made beforehand. The various parts are then to be carefully measured, and the dimensions one after another put upon the sketch already made.

It will be seen that the distance from the center of the shaft to the center of the crank pin can not be taken directly; but by measuring on the face of the crank from the lower edge of the collar to the lowest point of the shaft, we find the distance *x y* to be 19 in. From this subtract 4 in., the radius of the shaft, and to the remainder add 3 in., the radius of the collar, and we obtain the desired distance, 18 in.

Similarly, the length of the crank pin proper is 5 1-2 in.; the half of this, 2 3-4 in, plus 3-4 in., the thickness of the inner collar, gives 3 1-2 in. as the distance of the face of the crank from the vertical line *H K* through the center of the crank pin. This is an important line, being the plane of rotation, which passes through the center line of the cylinder; from this plane all side distances are estimated, such for example as the 16 1-2 in. to the nearer of the two collars on the main shaft, which limit its journal, 12 in. in length.

Now, it is very frequently the case that distances of vital importance can not be taken at all except by this roundabout process of making several indirect measurements, and adding some and perhaps subtracting others. And in connection with this, there is one feature to which we would call attention in the most emphatic manner, viz.: Having thus determined one required distance, it is a not uncommon case that in determining another one in a similar manner, a second set of figures is obtained, by manipulation with which the first distance can also be determined in another way. When this occurs, it would be a very awkward thing if upon making an instrumental drawing from the sketch the two values thus obtained should not be the same. The utmost care should therefore be taken to test this question while making the sketch—the figures should be compared, and if any discrepancy be detected, the observations should be repeated until the error is eliminated and the results made concordant.

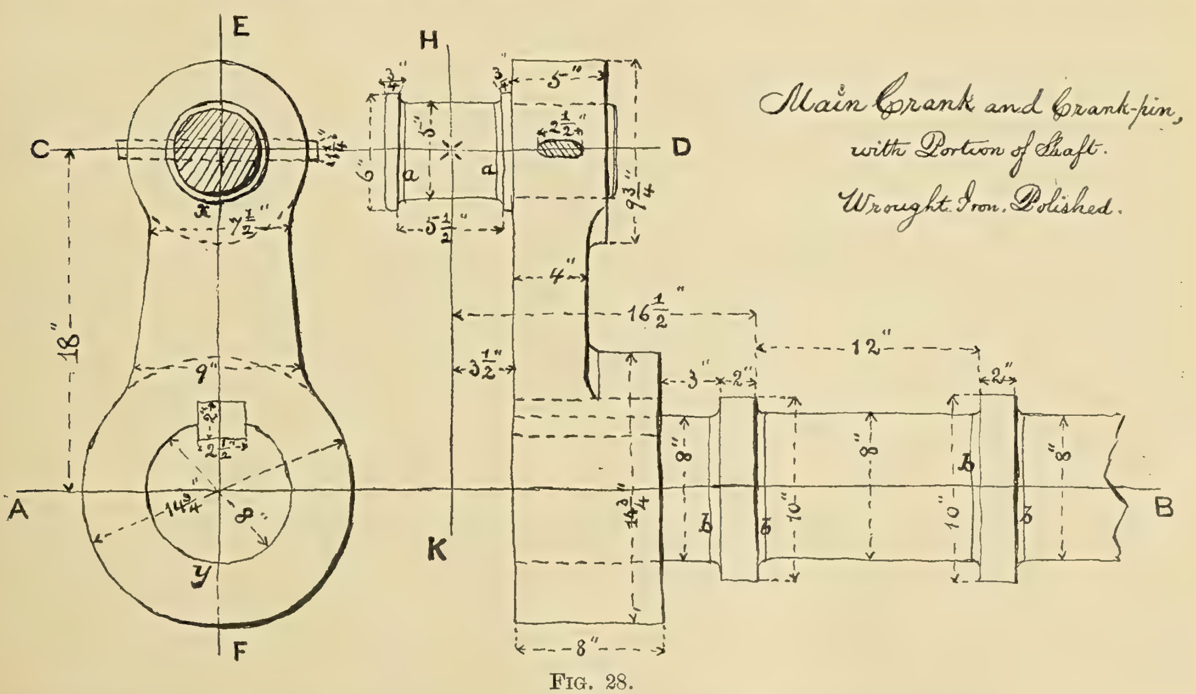


FIG. 28.

It is a well known fact that if a sharp corner, even a right angle, be formed at the junction of either a shaft or a crank pin with collars formed upon it, the liability to fracture is very much greater than if these junctions are rounded out, or, as it is technically called, *filleted*, as shown in the figure. The line of tangency between the fillet and the cylindrical body of the shaft or the pin is, abstractly speaking, an imaginary line, and therefore not entitled to be represented on the drawing. But if it be not shown, the existence of the fillet might be overlooked; particularly if, as is often necessary, its radius be small. But even a very small fillet is a great safeguard against fracture; and the chance of its being overlooked is absolutely prevented by drawing in, *in a hair line*, this imaginary line of tangency, as shown at *a a* on the crank pin, and *b b* on the shaft. There may be two opinions as to whether this improves the appearance of the drawing; but any one whose experience includes the breaking of a shaft by reason of its omission, will thereafter be inclined to think that it does.

Opinions also vary as to the methods of representing center lines and "dimension lines;" we prefer the style shown in the figure, where the center lines are drawn *full*, but very *fine*, while the dimension lines are drawn with *fine dashes*, less pronounced than those used for representing hidden outlines. As to the arrangement and location of the figures, the sketch illustrates one or two principles of general application, viz.: Each figure should be so placed as to be conspicuous—when it can be avoided, figures should not be placed near each other, or near any center line or any outline; and they should be so clearly written that all can be easily read, without the possibility of mistake.

Now, as intimated in the foregoing, the pieces in question could be reproduced by the aid of the sketch, whether in making it the proportions were preserved or not; provided only that the dimensions be clearly and correctly given. But obviously that sketch is the best which most closely resembles the exact drawing; and for several reasons it should be made to do so as nearly as may be, if time permits. For one thing, the habit of close observation is cultivated; and besides, impressions of relative dimensions are insensibly fixed in the mind, and what may be called a sense of mechanical proportion is developed; all of which is of the greatest value to any one who has to do with mechanism, and especially to a designer, who must at the outset depend to a great extent upon free hand sketches as records of his ideas. The ability to sketch in reasonably good proportion is to some extent a natural gift, but like many others it is one which can be cultivated, and greatly improved by practice; and we shall subsequently have occasion to indicate some lines in which such practice may be advantageously pursued with that object in view, without the aid of any artificial appliance.

But, confining our attention now to the production of a fair sketch of the crank and shaft shown in the cut, and supposing a reasonable time to be at disposal, the beginner will find his labor greatly lessened by the use of "cross section" paper; that is, paper divided into small squares by vertical and horizontal lines, either water marked or very faintly ruled; lines at regular intervals being made more pronounced, thus dividing the paper into larger squares for facility in counting the divisions; which may now be had in great variety, in single sheets, pads, and note books, of different sizes. If this be at hand, it is obviously the better course to begin by taking the leading dimensions, before drawing any lines upon the paper; because these can then be put in, by the aid of the subdivisions, very nearly if not absolutely at their proper relative distances from each other. And the minor details being in like manner also measured before they are drawn in, the whole sketch may be made in such a manner as to approximate quite closely to a drawing made to scale.

This will necessarily occupy somewhat more time than the proceeding first described; but on the other hand the result is very likely to be better. And no matter which method be pursued, it should always be kept in mind, that such a sketch is to be considered as a permanent record, and it should be such that a working drawing can be laid down from it, by either the one who made it, or by any one else, *at any subsequent time*. Too many tyros are apt to think that they themselves are to make the scale drawing, and to do it immediately; thus they content themselves with sketches so crude and obscure that no one else could ever use them, and they could not do so themselves two days after—an error which we hope that none of our readers will ever commit.

Current Matters of Interest.

An order for a large side wheel excursion steamer is reported placed with the Detroit Dry Dock Co. for the White Star line of Detroit.

An order for a 140 ft. steam yacht is reported to have been placed with Pusey & Jones, Wilmington, Del., by J. Rogers Maxwell, of New York.

The protected cruiser Chitose, built by the Union Iron Works for the Japanese Government, is reported to have made an average speed of 21.48 knots, with natural draft, on a six hours' run.

New York City is the owner of a considerable fleet of vessels. These are employed in the Police, Fire, Charities, Correction and Dock departments, and include a great variety of types of vessels. The gross value of these vessels is about $1,000,000, and they require an annual expenditure of about $150,000 to keep them in repair and pay the crews and purchase stores.

Returns for the year 1898 will probably show that the amount of tonnage entered and cleared at the port of New York will exceed that of any other port in the world. The number of entries from foreign ports at New York for the year, of all class of vessels, were 4,660, of which number 751 were American vessels. The total of British vessels was 2,573, of which 1,844 were steamships.

Improvements which have been made in recent years in the arrangements for carrying cattle on vessels are indicated by the record made by the S. S. Georgic. On the completion recently of her thirteenth round voyage across the Atlantic her record showed that she had carried more than 11,000 head of cattle without the loss of a single beast. In former years the percentage of losses of cattle on the hoof in the Atlantic trade was enormous.

It is Reported

That the torpedo boat Rowan, constructed by Moran Bros., of Seattle, showed a mean speed of over 27 knots for an hour's run on preliminary trial. Her estimated contract speed is 26 knots. She is a 170 ft. boat, with twin screw quadruple-expansion engines.

That the torpedo boat Davis reached a speed of 23 1-2 knots on her second trial. She was built at Wolff & Zwicker's yard at Portland, Ore. She is 146 ft. long and displaces 132 tons. Her contract speed is 22.5 knots, with 1,750 H. P. She is fitted with triple-expansion engines and Thornycroft water tube boilers.

That a new steamship line will be established between Norfolk, Va., and South American and West Indian ports, the company to be known as the South Atlantic Steamship Co. The promoters claim that many of the shipments now made, via New York, will, upon the establishment of the line, go by way of Norfolk.

QUERIES AND ANSWERS.

(Communications intended for this department will not receive attention unless accompanied by the full name and address of the sender, which will be considered confidential).

Q.—How can I find the clearance of an engine by the indicator diagrams? Also please give method for finding the evaporation by the indicator diagram. Kindly go into detail about clearance especially. I have a 25 in. by 40 in. by 68 in. by 42 in. engine that I have taken some splendid diagrams from and under actual test of weighing coal, etc., driving hard in a heavy head sea, worked down as low as 1.7 per horse power. GREAT LAKES.

A.—The determination of the clearance from the indicator diagram proceeds upon the assumption that the expansion or compression curve is a simple hyperbola. This is a wholly unsafe assumption to make, and the result is likely to be entirely misleading and worthless. These curves depend upon a variety of circumstances and frequently they depart very considerably from the simple hyperbola in form. They are affected by varying amounts of water suspended in the steam, by the action of steam jackets if provided, by leaks in steam valve, or in the piston, etc. With the expansion curve a slight departure from the common hyperbola will be enough to make a very considerable error in the clearance as determined by this method. With the compression curve the departure is often very considerable, so that here also the basis of the method is entirely unreliable. If in the cases you have tried the value in the H. P. cylinder comes out about as it should, it is largely a matter of chance and means presumably that under the especial circumstances the curve is nearly hyperbolic. In the I. P. and L. P. cylinders the method is, in principle, no less nor more accurate than in the H. P. It must be remembered in any case that use can be made only of that part of the expansion curve after cut off and before release, or of that part of the compression curve after exhaust closure and before steam opening. The point of the whole matter is that this method of finding the clearance is wholly untrustworthy, and there is no use in trying to do anything with it. It is a sheer waste of time.

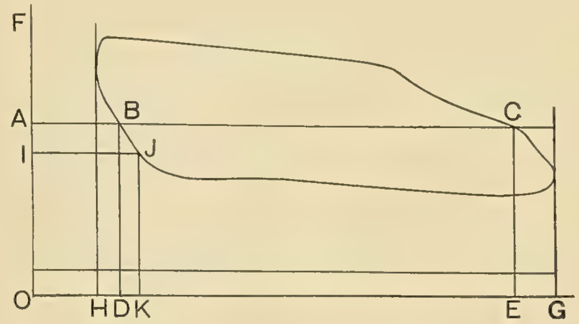
The clearance should be determined either by measurement and computation from the drawings, or by filling it with water and measuring the amount required. There are several methods of procedure. In the first place the valve must be disconnected and blocked in mid position, thus covering the ports. Care must also be taken to provide by the use of putty, if necessary, against leakage at either the valve or piston. Then place the engine on the center and by means of the indicator pipe fill the clearance volume with water by pailfuls, weighing each pailful before pouring in, and the amount left over in the last pailful. Then knowing the weight of the pail, the total weight of water poured in may be found. This reduced to volume by taking 62.5 lb. to the cubic foot will give the clearance volume in cubic feet, and this divided by the volume of the piston displacement will give the clearance percentage. If salt water were used, 64 instead of 62.5 would be used in reducing to volume.

Somewhat differently the mode of procedure may be as follows: Place the engine just one inch off the center as shown by measurements on the guides. Fill up the volume as before and note the weight required. Then move the engine up to the center slowly, catching the water as it is forced out and weighing as before. The amount forced out corresponds to 1 in. of piston displacement. Subtract this amount from the total, and the remainder represents the water in the clearance. Divide the latter by the amount representing one inch of piston travel, and the quotient is the number of inches corresponding to the clearance. This divided by the stroke will give the clearance percentage.

As an illustration of the first mode of procedure, suppose dia. = 22 in., stroke = 40 in., weight of water to fill clearance = 85 lb. Then volume of clearance = $85 \div 62.5 = 1.36$ cu. ft. The volume of piston displacement = $3.1416 \times 11 \times 11 \times 40 \div 1728 = 8.8$ cu. ft., nearly. Hence clearance percentage = $1.36 \div 8.8 = 15.45$ per cent.

For the second mode of procedure let the figures be as follows: Total weight of water with engine 1 in. off center = 99 lb. Weight of water forced out when engine is brought to center = 13.5 lb. Difference = 85.5 lb. Then 13.5 lb. represents 1 in. of piston travel, and 85.5 lb. the whole clearance. Hence $85.5 \div 13.5 = 6.33$ in. = number of inches of piston travel giving a volume equal to that in the clearance. Hence 6.33 in. $\div$ 40 in. = 15.8 per cent = clearance percentage.

In regard to the second question, the evaporation derived from the indicator card is also inaccurate, misleading and worthless, unless it is remembered that it shows simply the amount of water present in the form of *vapor* and not the total amount of mixed *water* and *vapor*. This total amount may be from nothing to 50 or 100 per cent greater than the amount of vapor, depending on circumstances, and at what point of the card the determination is made. Remembering then that this determination relates simply to the amount of vapor, and not to the total amount of water in the form of both liquid and vapor, we may proceed as follows: Referring to the figure here printed, we draw



the line of zero pressure, absolute, and the clearance line *O F* such that *O H* ÷ *H G* equals the clearance percentage as determined by computation or measurement. We then select a point *C* on the card just before the point of exhaust opening, and draw the line *A C*. This line represents the total volume of steam at a pressure *E C*, present in the cylinder at this point of the stroke. Of this total amount, a certain part is rejected during exhaust, and the remainder is shut in by the exhaust closure. When the latter has been compressed up to the pressure *D B* equal to *E C*, the volume occupied is *A B*. Hence the amount actually exhausted corresponds to a volume *B C* at pressure *E C*. The volume of total piston displacement is represented by *H G*. Hence the volume represented by *B C* is the same fraction of the piston displacement that the length *B C* is of *H G*. In this way the volume corresponding to *B C* is found. Then from steam tables we find the weight per cubic foot at the pressure *E C*, and multiplying this by the volume, we have the steam per stroke in this end of the cylinder. This entire operation must then be repeated and the corresponding amount found for the other end of the cylinder. The sum will be the amount per revolution, and then from the known revolutions per minute or per hour, the amount per minute or per hour may be found, and dividing the latter by the I. H. P. we shall have the amount per I. H. P. per hour. In some cases the best point at which to take the amount of compression steam may seem to be other than *B*, as at *J* for example. In such case the amount of compression steam is taken as that corresponding to the volume *I J* and pressure *K J*, and is subtracted from that corresponding to volume *A C* and pressure *E C*. If desired the volume of the piston rod may be allowed for in finding the volume of piston displacement in the head end.

As an illustration take the following relating to the H. P. cylinder of a triple-expansion engine: Dia., 22 in.; stroke, 40 in.; dia. of piston rod, 5 in; clearance, 15 per cent.

Then:

Volume of piston displacement, head end = 8.80
Volume of piston displacement, crank end = 8.35

For head end let *B C* = 3.45 in. and *H G* = 4 in. Then volume corresponding to *B C* = $3.45 \div 4 \times 8.8 = 7.59$. Let the pressure *E C* be 80 lb. above atmosphere or 95 lb. absolute. Then weight of 1 cu. ft. at this pressure as given by steam tables is .2165 lb.

Hence:

Weight of steam in head end for one stroke = $.2165 \times 7.59 = 1.643$. For crank end let *B C* = 3.3 in. and *H G* = 4 in. Then volume corresponding to *B C* = $3.3 \div 4 \times 8.35 = 6.89$. Let the pressure *E C* be 82 lb. above atmosphere or 97 lb. absolute. Then weight of 1 cu. ft. at this pressure as given by steam tables is .2208 lb.

Hence:

Weight of steam in crank end for one stroke = .2208 × 6.89 = 1.521. Then weight of steam per revolution = 1.643 + 1.521 = 3.164. The revolutions were 88 per minute and the total I. H. P. developed by the engine was 1,544. Hence the steam per I. H. P. per hour as accounted for by the H. P. indicator card is:

$$\text{Weight} = \frac{3.164 \times 88 \times 60}{1544} = 10.82 \text{ lbs.}$$

The actual steam consumption in this case was about 14 lb. per I. H. P. per hour, so that the steam thus accounted for by the indicator is only 10.82 ÷ 14 or 77 per cent of the whole amount.

Q.—Please figure these out:

For compound condensing engines with two or more cylinders when the cranks are not overhung:

$$S = \sqrt[3]{\frac{C \times P \times D^2}{f\left(2 + \frac{D^2}{d^2}\right)}}$$

$$P = \frac{f \times S^3}{C \times D^2}\left(2 + \frac{D^2}{d^2}\right)$$

Where S = diameter of shaft in inches; d^2 = square of diameter of high pressure cylinder in inches or sum of squares of diameters when there are two or more high pressure cylinders; D^2 = square of diameter of low pressure cylinder in inches or sum of squares of diameters when there are two or more low pressure cylinders; P = absolute pressure in pounds per square inch, that is, boiler pressure plus 15 lb.; C = length of crank in inches; f = constant from the table.

Note.—Intermediate pressure cylinders do not appear in the formulæ.

For ordinary condensing engines with one, two or more cylinders when the cranks are not overhung:

$$S = \sqrt[3]{\frac{C \times P \times D^2}{3 \times f}}$$

$$P = \frac{3 \times f \times S^3}{C \times D^2}$$

Where S = diameter of shaft in inches; D^2 = square of diameter of cylinders in inches or sum of squares of diameters where there are two or more cylinders; P = absolute pressure in pounds per square inch, that is, boiler pressure plus 15 lb.; C = length of crank in inches; f = constant from table.

The first is a fore and aft compound engine of 28 in. dia. high pressure and 54 in. dia. low pressure cylinders with 36 in. stroke. Steam pressure at boiler 136 lb.; angle between cranks 90 deg. $f = 1047$.

The second is a double condensing engine with cylinders 24 in. dia. and 21 in. stroke; steam pressure 93 lb.; angle of cranks 90 deg. $f = 1047$. CANADA.

A.—The formulae which you quote are the British Board of Trade Rules. For the first case we have the following values:

$d = 28$
$D = 54$
$C = 18$
$f = 1047$
$P = 136 + 15 = 151$

We find first the square of d or 28, which is 784, and the square of D or 54, which is 2916. We then divide 2916 by 784 and find 3.72 for the value of $D^2 \div d^2$ in the denominator. To this we add 2 and find 5.72 as the value of the parenthesis in the denominator. We then multiply together 18 × 151 × 2916 and divide by 1047 × 5.72, finding 1323.+ as the result. We next take the cube root of this number and find 10.98 inches. Taking the nearest shop figures we should have 11 in. as the diameter of the shaft.

For the second case the values are:

$D = 24$ and $D^2 = 576$
$C = 10.5$
$P = 93 + 15 = 108$
$f = 1047$

We then multiply 10.5 × 108 × 576 and divide by 3 × 1047, or 3141, finding 207.9 as the result. We then take the cube root of this number and find 5.92 in. Taking the nearest shop figures we should have 6 in. as the diameter of the shaft.

Q.—How is it that a small engine turning, say, 300 or 400 revolutions per minute will develop more horse power than an engine with cylinders over twice the size but only turning, say, 150 revolutions per minute, the steam being the same? Does it mean that the small engine could drive a boat as fast as the larger one? H. M. M.

A.—*Horse power* means a certain amount of work done per minute, and *work* depends on two things—pressure or load and speed or distance traveled per minute. To illustrate, suppose you are hoisting bricks by hand with a simple block and fall, and you hoist 100 lb. 30 ft. high in one minute. Then you have done 30 × 100 or 3,000 ft. lbs. of work. If you hoisted 70 lbs. 50 ft. the work would be 3,500 ft. lb. If the load was 50 lb. and the height 60 ft. the work would be 3,000 ft. lb. as at first. What you have lost in the load you have made up in distance. Similarly if the load was 200 lb. and the height 15 ft. the work would still be 3,000 ft. lb. What is lost in height is made up in load. The same with the two engines. Suppose the mean pressure and stroke to be the same, the cylinder area for the first to be 40 sq. in. and revolutions 150, while cylinder area for the second is 20 sq. in. and revolutions 300. Then the power developed will be the same in each case. What the larger engine loses in revolutions it makes up in area of piston, and so in total pressure or load. If the small engine should make 400 revolutions, then the power developed would be greater than for the larger engine at 150 revolutions. With the first engine at 150 revolutions and the second at 300, each fitted to a properly designed propeller, the speed of boat would be the same, provided of course that each propeller had the proper immersion.

Q.—Please add to the answer in the January issue something about wooden vessels. KEY WEST.

A.—Well, instead of the bowl made of sheet iron take a bowl made of light wood, say yellow pine, and bore a hole in the bottom. Water enters, but the bowl still floats. Why? Simply because the wood floats naturally. That is, its weight is less than that of an equal volume of water, and hence the necessary buoyancy is gained by the displacement of the material of the bowl before the immersion is complete.

The ordinary wooden ship, including fittings, metal fastenings, etc., is usually too heavy to float in this way, and hence will sink when invaded by water. Suppose, however, that we have such a vessel with the hold full of lumber? When water comes in the lumber provides effective displacement, and thus adds to the buoyancy derived from the structure of the vessel. In such case the vessel may float instead of sinking. Why? Simply because the lumber helps displace the water and adds to the available buoyancy, so that the total amount equals the total weight, vessel and cargo, before the immersion is completed. In this way it might be possible for a light steel vessel to float if water-logged with a hold full of light lumber. This is exactly similar in principle to encasing a piece of pine with thin sheet iron. The combination will float, while the iron alone, with water in the inside, will sink.

These general principles apply to all kinds of floating bodies, the battleship, the Atlantic liner, the schooner and the rowboat. The buoyancy must equal the weight, and the ship or boat floats with a good freeboard because a buoyancy equal to the weight is gained before the immersion is complete. Thus a battleship if immersed to the deck-edge would be subject to an upward buoyant force of some 16,000 or 18,000 tons. But as the battleship with all equipments weighs only some 11,000 tons, let us suppose, an upward buoyancy sufficient to balance this is gained with a considerable part of the hull still above the water line.

If the general principles given here and in the previous answer are kept clearly in mind they will serve to explain any and all problems connected with the floating of a body, whether it be simple or complex.

It is understood that the Navy Department will shortly offer for sale a number of the auxiliary vessels purchased during the Spanish war and that the vessels offered will include a number of steam yachts.

A survey of the Government property at League Island is being made, with a view to the construction of a great concrete naval dock there which is to be over 700 ft. long, and wide and deep in proportion. A large dock will also be built at Boston, Mass.

TRADE PUBLICATIONS.

Users of anchors should have a copy of the catalogue just issued by the Baldt Anchor Co., Chester, Pa. This patent anchor has received much attention and has been approved by the Lloyds Register. Several excellent testimonials are given, speaking in the highest terms of the anchor, by those who have given it practical test.

Users of wood working machinery will be interested in an illustrated catalogue of special wood working machinery issued by Baxter D. Whitney, Winchendon, Mass. It is one of the best specimens of the printer's art received in this office for a long time. So much wook working machinery is used in shipyards that this catalogue should be had by all interested.

The latest bulletin issued by the Sturtevant Co., Jamaica Plain, Mass., is devoted to electrical fans and is designated as Bulletin H, which can be had by writing for a copy. It comprises eight pages and is printed in the usual Sturtevant manner, giving a great many varieties of fans, including a special type of suspended fan designed especially for use on board ship.

Draughtsmen and others who have lettering to do will be interested in the pocket sized catalogue devoted to the Tampograph, a device manufactured by the Tampograph Co., Wilmington, Del. It is a simple mechanical device for designing and executing all sorts of hand lettering on drawings, maps, etc. The full operation of the device is explained in the catalogue.

"Who Uses Mechanical Draft?" is the question on the cover of an unusually attractive book issued by the Sturtevant Co., Jamaica Plain, Mass. The question is answered by a very large list of names where either forced or induced draft is used, and includes a large number of vessels in the Navy, besides many of the best known steamships and steam yachts in the country.

Drop forgings, as manufactured by J. H. Williams & Co., Brooklyn, N. Y., receive very thorough attention in a 40-page catalogue just issued. The line of forgings manufactured by this firm is fully described, giving sizes, prices and all other information that could be asked for. It is a very well printed catalogue and is thoroughly illustrated with the best of wood cuts.

"Pencilings" is the title of a very attractive and fully illustrated book issued by the Joseph Dixon Crucible Co., Jersey City, N. J. It gives quite a history of the graphite and pencil industry of the country and gives information which is useful for draughtsmen and other users of pencils. Several pictures in color are also given showing what can be done with colored crayons.

A cloth bound catalogue of more than sixty pages is received from F. Hennebohle, South Chicago and Erie avenues, South Chicago, Ill. Practically every page contains some type of specialties manufactured by this company. Many of these specialties are adapted to marine work. Copy of the catalogue should be in the hands of everybody interested in steam goods.

Lundell Motor Catalogue No. 58 is just at hand from the Sprague Electric Co., 20 Broad street, New York. It is 7 by 9 inches in size and bound in an exceptionally effective cover of rich green paper, printed in red and gold. The catalogue comprises over seventy pages and is fully illustrated with the very best of engravings, and altogether is an exceptionally fine specimen of the printer's art. It contains a great deal of valuable information regarding the subject of electricity, together with tables and other information, making it a valuable publication. A series of pictures is published showing the many special adaptations of motors to machine tools and other uses.

The Barnes Tool Co., New Haven, Conn., illustrates and describes many tools especially adapted to many uses in the marine field in a catalogue just received. These include pipe and other wrenches, a line of sawing machines and steering wheels designed for vessels of all sizes and qualities. These wheels should receive the attention of every yachtsman.

Various rubber goods manufactured by the Revere Rubber Co., 63 Franklin street, Boston, Mass., are well illustrated and described in a set of a half dozen or so folders and catalogues about 3 by 6 inches in size. The packing catalogue should be in the hands of every user of packing, as it is not only neatly printed in two colors, but contains many illustrations of the various kinds of packing made.

Improved lubricating devices manufactured by the Detroit Sheet Metal & Brass Works, Detroit, Mich., are fully described and very neatly illustrated in the catalogue just received. The cover is very dark green, printed in gold letters. There is a full line of lubricators, oil pumps and kindred devices shown, with incidental reference to a line of marine hardware, rafts, ventilators, etc. There is much matter valuable for reference in addition to the above, making the catalogue exceedingly useful.

The Norton patent ball bearing lifting jacks are fully described in a catalogue just at hand. A great many types of jacks are illustrated and much information is given regarding the subject in general and each type of jack in particular, and a number of testimonials are reproduced. There are many uses for jacks in marine work, and those interested in the subject should have a copy of this catalogue, which can be had by writing to the manufacturer, A. O. Norton, 167 Oliver street, Boston, Mass.

Calendars for 1899 Received.

We are informed by the publishers of these calendars that copies can be had on application up to the limit of the supply.

H. B. Leonard & Co., 141 Milk street, Boston, Mass., containing lithographed pictures of the many uses for "Brilliant" metal polish.

West & Peachey, Simcoe, Ont., Canada, containing pictures illustrating the Alligator steam warping tugs manufactured by this firm.

George I. Roberts & Bro., 471 Fourth avenue, New York, a colored lithograph representing the battleship Oregon pursuing the Cristobal Colon.

George B. Carpenter & Co., 202-208 South Water street, Chicago, Ill., a fine 4 by 8 half-tone picture, with the busy sail-loft scene in this firm's establishment.

The William Powell Co., Cincinnati, O., printed in three colors and showing a valve, whistle and other specialties; also a large red star on a brass regrinding valve.

American Steam Gauge Co., 36 Chardon street, Boston, Mass., containing a very artistic color lithograph of two pointers hunting, and framed effectively in a gilt border.

William Bishop's Sons, 205 South street, New York, an embossed calendar in white and gold, containing an excellent picture of the Shakespeare Memorial building at Stratford-on-Avon.

Dearborn Drug & Chemical Works, Rialto Building, Chicago, Ill., two calendars, one large one containing a lithographed picture of old Fort Dearborn, the first building in Chicago; the other a small one, pocket size, printed in gilt on celluloid.

La Favorite Rubber Manufacturing Co., Paterson, N. J., with pictures of Perry packing and other specialties, each month's sheet having an excellent portrait of some Naval Officer or General prominently identified with the recent war.

American Manufacturing Co., 67 Wall street, New York, a very handy desk calendar, 5 by 7 inches in size, printed in blue and bordered with cordage, embossed and gilded. Inside the folder is much important information regarding rope.

BUSINESS NOTES.

Large Ship Chandlery Concern.—S. P. Blackburn & Co., ship chandlers, with stores in New York, Boston and Philadelphia, have opened a branch house at 502 East Lombard St., Baltimore, Md.

Slight Change in Name.—The Lackawanna Lubricating Co., of Scranton, Pa., has extended its business and changed its name to the Lackawanna Lubricator & Mfg. Co., in order to carry on a more extensive business in manufacturing cylinder lubricators and grease cups.

More Shop Room.—The Morse Iron Works Co., foot of 26th St., Brooklyn, N. Y., has been so crowded with work that it has taken an adjoining warehouse for use as additional shop room. This increases its capacity very much and greatly improves its facility for rapid and efficient work.

Removal of Office.—The Philadelphia office of the C & C Electric Co. has been removed from 633 Arch St, to much larger and more attractive quarters at 45 North 7th St. The office will remain in the hands of William Myers, who is well known to the many friends of this company.

Tube Expanders.—The Ferguson patent self-feed roller-tube expander manufactured by A. L. Henderer's Sons, Wilmington, Del., is illustrated in the advertisement of this company elsewhere. This firm also makes a line of hydraulic jacks and punches, pipe vises and other boilermakers' specialties.

Change in Name Only.—The business heretofore carried on by William Porter's Sons, 271 Pearl St., New York, in all kinds of lamps and lanterns for marine uses has been changed into a corporation under the name of William Porter's Sons Co. This change became necessary owing to the large increase and extension of the company's business.

An Economical Vessel.—The owners of the S.S. C. A. Black, 6,800 tons, believe her the most economical freight carrier, not only on the lakes, but in the country. A report of a recent test gave a consumption of 1.46 lb. coal per I. H. P. per hour. This efficiency is largely credited to the Howden hot draft, installed by the Detroit Dry Dock Co., Detroit, Mich.

Buckley Water Tube Boiler.—The Buckley water tube boilers, manufactured by the Rochester Machine Tool Works, Rochester, N. Y., have found extensive use in yachts and launches and have been put in many boats for the United States Government. The steaming and other qualities of these boilers are well shown in the circulars sent out by the company to all inquirers.

Metal Polish.—Ayrolite is a metal polish which has found extensive use in marine trade because of its many features. The loss by evaporation on liquid polishes and melting paste polishes is done away with. Ayrolite is used to polish brightly any finished metal; is guaranteed by its manufacturers free from acids, grease or grit, and not to injure even the finest ware. The sample package offered for 10 cents is believed to be equal to a pint of ordinary liquid polish. It is manufactured by the Ayrolite Co., 625 Second Ave., Pittsburg, Pa.

The Paragon Boiler.—Reference has been made before in these columns to the Paragon boiler, manufactured by Captain M. De Puy, 19 South St., New York, and to the record of the steam canal boat Paragon propelling herself and towing ten fully loaded canal boats from Albany to New York, the weight of all the cargoes being 3,280 tons. We are now informed that the boiler has proved to be such a big steamer that the grate area has been reduced one-half. The draft has been more evenly distributed and improved by putting retarders in eighty of the upper tubes. The owners of the steamer Paragon have a sister boat which, during a recent test of the two boats, burned 43 tons of soft coal in 30 days against 16 tons for the Paragon, doing similar work.

Almy Boilers.—A fine steam yacht recently ordered by D. W. & A. C. James, of the New York Yacht Club, will have, among other features, Almy boilers, furnished by the Almy Water Tube Boiler Co., Providence, R. I.

A Miniature Anchor.—The Baldt Anchor Co., Chester, Pa., is sending out to its friends a model of the Baldt stockless patent anchor, about 1 1-4 in. long. It is nickel plated and makes a very novel and attractive souvenir. All readers of Marine Engineering who wish one need only to send their name and address and refer to this publication.

The Trigg Shipbuilding Co.—The Trigg Shipbuilding Co., Richmond, Va., which was only formally organized a few weeks ago, has already begun work on the three torpedo boats which it has contract for. The plant is in full working order and a full force is now in active work, giving the company every facility for branching out and filling any orders that may be received.

Quartet Chime Whistle.—Every user of a steam whistle will be interested in the one manufactured and advertised by the Kinsley Mfg. Co., Bridgeport, Conn. This is intended to be as musical a whistle as can be made and has been introduced into many of the best yachts and steam vessels in the country. A good sounding whistle is of such importance that all interested will no doubt want to investigate.

An Efficient Launch.—The Daimler Mfg. Co., Long Island City, N. Y., is in receipt of a letter from W. A. Thompson, U. S. Engineers' Office, La Crosse, Wis., which says that a 21-ft. 2 horse-power Daimler launch purchased in 1893 has been used for nearly six years on work for improving the Mississippi river and has been run about 25,000 miles with excellent satisfaction. This certainly is a high compliment to the Daimler engine and hull.

Boiler Compound.—The Dearborn Drug & Chemical Works, Rialto Building, Chicago, Ill., have established a marine department, under the charge of E. P. Gould, a marine engineer of much experience. In order that the compound furnished for each case shall be adapted to the needs of the ship, the company offers to analyze without charge samples of water sent in and to supply compound designed to overcome the impurities of a sample. The purpose of the department is to reduce corrosion and injury to marine boilers to as low a point as possible, and as much attention is given to the seacoast as to the lakes. One of the formulae is designed especially to reduce the injurious qualities of salt water to a minimum when it is necessary to use this in a boiler. Further information regarding the marine department can be had from the company.

Prosperity at Harlan & Hollingsworth's.—At a recent meeting of the Board of Directors of the Harlan & Hollingsworth Co., Wilmington, Del., to fill the vacancy in the office of president, caused by the death of the late J. Taylor Gause, H. T. Gause was elected president, H. W. Gause vice-president and secretary, and J. Rodney Gause to the vacant directorship. The above, with S. K. Smith, treasurer, and T. Jackson Shaw, superintending engineer, completes the Board of Directors. The following changes have also been made in the organization of the plant: W. F. Carnos, assistant superintending engineer; E. B. Sadtler, superintendent of hull construction; J. Rodney Gause, assistant superintendent of hull construction; Thomas Benson, superintendent of dock repairs. This company has recently received a contract from the New York and Porto Rico S.S. Co. for a sister ship to the "Ponce," and from the Red D Line for a twin screw freight and passenger steamer, 277 ft. long. During the year 1898 this company signed many contracts for vessels, making the record one of the best in its history. A large amount of new machinery has recently been added to the establishment, and in every way the equipment of the whole yard has been brought up to a high state of efficiency.

Launch Outfit.—A compact and convenient power plant for launches and other uses where a small power plant is required is advertised elsewhere by the Shortt Engine Co., 143 Liberty St., New York. Detailed information can be had by inquiring of the company.

Cold Process of Galvanizing.—The U. S. Electro Galvanizing Co., 346 Broadway, New York, is finding many users of its cold process for galvanizing. In addition to its commercial work, it is doing work for the U. S. Navy. This system widens the use of galvanizing.

Clean Oil.—The Famous oil purifier, manufactured by the Famous Filter Co., 314 North Main St., St. Louis, Mo., is used extensively in many manufacturing establishments, as well as by the United States Navy. This filter is guaranteed to extract impurities and is sent on 60 days' trial.

Two Fine Launches.—The International Navigation Co. has ordered from the Marine Vapor Engine Co., Jersey City, N. J., two specially built 30-ft. launches equipped with 12 horse-power Alco engines, to be used as tenders for the S.S. New York, which is about to make a cruise through the West Indies with excursionists.

Crumlish Forges.—We are informed that 46 per cent of the forges built by the Crumlish Forge Co., Buffalo, N. Y., in 1898 were supplied to shipyards on the lakes and along the seacoast. The demand for these forges has so increased that the company has moved to much larger and better equipped quarters at 18-20 Elk St.

A Big Casting.—The Penn Steel Casting & Machine Co., Chester, Pa., recently received an order for a rudder for the S.S. Kensington. The casting, 28 1-2 ft. wide, weighing over ten tons, was ready in less than the fourteen days given in which to finish the work, demonstrating the capacity of this company to give prompt attention to the orders of this kind.

Loss by Fire.—Caskey Bros.' foundry, Newport News, Va., was destroyed by fire last month, causing serious loss, especially as the company was full of orders at the time. The loss is placed at about $20,-000, covered by insurance. The company will undoubtedly be able to resume business soon and be able to fill all orders for Caskey's manganese bronze and white lining metal.

ZINC WHITE IN MARINE PAINTING.

Within a few years after the discovery of the modern process for making zinc white, the French naval authorities, after severe tests, ordered its use to the exclusion of white lead on the interior of all vessels of the French navy. Experience has confirmed its superiority for painting structures exposed to sea-air and sea-water, and the French navy as well as the French steamship companies now universally employ it, while it is also the official base for painting lighthouses and Government work on the seashore. The French Marine authorities also use it for painting galvanized iron plates, the hulls of torpedo boats, the shells of metal pontoons, etc.

That the French navy should have been earliest to adopt this practice is natural, since zinc white was first generally introduced in France. But the naval authorities of the United States, having made their own experiments with the same results, have adopted zinc white as the fixed component of all paints used either in the Navy or by the Lighthouse Establishment. The famous "White Squadron" obtained its color from zinc white, and remained white because zinc does not change color. Ten tons of American zinc white is the cruising allotment for each ship, and it is used liberally and effectively.

Similar testimony is found in the U. S. Lighthouse specifications, which require, for white, a mixture of one-fourth lead and three-fourths zinc, and for tinted paints, American zinc white and yellow ochre, with no lead. "The colored paints are wanted for outside use and are required to withstand the bleaching effects of salt water and sunlight."

The durability of zinc white is due to its chemical stability and to the large proportion of oil it carries to the painted surface. No other white pigment approaches it in this respect. It is the one white paint material that is capable of resisting salt water and salt air. Added to other materials it shields them and gives them durability.

Advt. NEW JERSEY ZINC CO.

Useful Notes is the name of a little pamphlet filled with information for transatlantic travelers and published by Pitt & Scott, 37 Broadway, New York. This firm is one of the best known tourist agents and private express companies, and long experience in this particular field has enabled it to know just what sort of information the intending traveler needs. It is a compact little book, to be carried in the waistcoat pocket. Copies can be had by applying to the firm.

MARINE ENGINEERING.

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GERMAN BUILDER CLAIMS THE FASTEST VESSEL AFLOAT—35.2 KNOTS.

Another claimant for the honors of the fastest vessel afloat has appeared in the famous German builder, F. Schichau, of Elbing, who has turned out a torpedo-boat destroyer with the astounding rate of speed of 35.2 knots. An account of this boat, together with a photograph taken at the maximum speed, are here reproduced from our German contemporary *Ueberall*. From the photograph one would hardly get the impression that the boat was traveling at such high speed, for there is but little noticeable change of trim and none of the "fuss and feathers" which generally marks high speed runs. In land miles the speed is equivalent to 40.55 miles an hour, or little less than many limited railroad trains. A translation of the article reads:

Since the appearance of the first torpedo boats, 20 years ago, the speed of this type of boat has been increased the rate of about a knot a year. The first small English torpedo boats did not make more than 15 knots, and to-day the latest torpedo-boat destroyers built in Germany have reached a speed of 35.2 knots. The foreign built boats of the same class built in 1898 on the contrary have barely exceeded 30 knots on their trial trips, with the exception of the English trial torpedo boat "Turbinia," built last year, which is said to have reached a speed of 32.75 knots. This boat is equipped with three steam turbines, each of which drives a shaft with three propellers, making a total of nine propellers. This great number of propellers is rather cumbersome, but the greatest disadvantage of the "Turbinia" lies in the fact of her inability to make any speed going astern.

The torpedo-boat destroyer shown above, photographed during its highest rate of speed, belongs to a series of four boats built for the Chinese Navy by F. Schichau, of Elbing, last summer. Each boat has twin triple-expansion engines, each driving one propeller. Fully equipped, and with 67 tons of coal on board, these Schichau torpedo-boat destroyers made a speed of 33.6 knots, which is one knot faster than the "Turbinia" when the latter was light, and the Schichau boats ran 35.2 knots when light, exceeding the speed of the "Turbinia" by 2 1-2 knots. The speed of 35.2 knots per hour represents a speed of 65.2 kilometers, and on the continent there are in Germany only eighteen, in Austria and France three each, and in Belgium only one express train which exceed this speed.

The latest results have demonstrated that the German builders have at last succeeded in outstripping all foreign competition in the construction of these speedy boats.

CHINESE TORPEDO-BOAT DESTROYER, WITH RECORD OF 35.2 KNOTS—LIGHT.

It will be some consolation to the navies of the civilized powers that these boats are for China. With Chinese crews and Chinese methods it is doubtful if the trial speeds will be attained in actual service.

SLIP AND ITS RELATION TO THE PROBLEM OF SCREW PROPULSION.

BY EDMUND LEAVENWORTH.

(*Second and last Installment.*)

So far as there is any agreement among engineers and writers on this subject, the definition given in the concluding paragraph (c) of the first installment of this article (page 16, January, 1899, issue)—that given by an equality of developed thrusts—is the one implied in the use of the word *slip* as applied to a propeller working in a variable stream such as the wake.

INFLUENCE OF SLIP ON THE PERFORMANCE OF THE PROPELLER.

Having now shown what slip is, both in its simple and more complex aspects, let us proceed to a discussion of the influence of slip on the performance of the propeller.

We should now recall that the fundamental purpose of the propeller is to gain a propulsive thrust by giving to the water in which it works a sternward motion. Furthermore, the amount of such thrust will increase with the amount of water acted on, and with the change in its velocity. Hence, with the same amount of water acted on the greater the change or slip of the water the greater the thrust, and as the slip of the water and that of the propeller increase together, it follows that the greater the slip of the propeller the greater the thrust developed. This is illustrated in Fig. 1, which shows the nature of the relation between

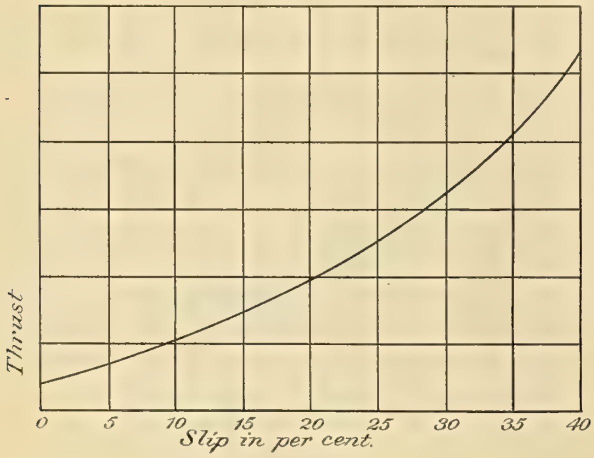


Fig. 1.

thrust and true slip, the speed being constant and the change in slip being produced by a change in revolutions; or again in Fig. 2, which shows the nature of the relation between thrust and true slip, the revolutions being constant and the change in slip being produced by a variation in speed. It thus appears that if a given thrust is desired it may be obtained by acting on a small amount of water with a large slip, or a large amount with a small slip, or by any intermediate combination of amount and slip which shall produce the necessary thrust. It follows further, since the amount of water acted on varies directly with the size of the propeller, that a given thrust may be obtained with a large propeller working at a low slip, or a small one at a high slip, or by intermediate combinations of size and slip as may be necessary to produce the thrust desired. The important point is to remember that size may be exchanged for slip and vice versa.

But the effect of slip on thrust is not the only influence with which we are concerned.

It is the duty of a propeller not only to develop a propulsive thrust, but to do so with the minimum expenditure of turning effort, and to drive the ship through the water with the minimum expenditure of

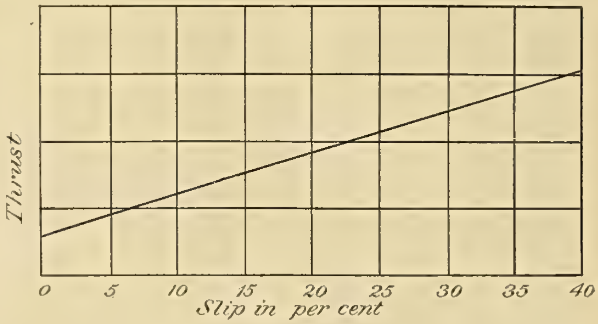


Fig. 2.

power in the engine. The question of *efficiency* is thus introduced. The idea fundamental in this term is a ratio of returns to investment. So far as the propeller is concerned, it is the ratio of the useful work (thrust multiplied by distance traveled) to the work absorbed by the propeller. The *distance traveled* may have two meanings, however, according as we consider the motion of the ship through the surrounding water, or that of the propeller through the wake. But, as already shown, these two speeds subtracted from the product $p\ N$ (pitch multiplied by revolutions) determine the two kinds of slip, *apparent* and *true*. It is, therefore, clear that the useful work and the efficiency will depend on the slip, and that there will be two kinds of efficiency, *apparent* and *true*, corresponding to the two kinds of slip. When not otherwise stated, the *true* slip and the corresponding *true* efficiency will, in the present article, be always understood.

The nature of the relation between slip and efficiency is shown graphically in Fig. 3. For A B the best efficiency is about 69 per cent, which is seen to occur at about 22 per cent slip, while for C D the same best value is found at about 20 per cent slip. These curves are characteristic of the relation between efficiency and slip. For low values of the slip the efficiency is very low, but increases rapidly as the slip increases, until a maximum value is reached, usually somewhere about 20 per cent slip. From this point the efficiency falls off more slowly as the slip increases, as shown by the curves from E to B and D. The causes of this complicated relation between slip and efficiency are beyond the limits of the present article. The important points are that the efficiency does not necessarily increase with a decrease of slip, as is so often believed to be the case, and that very low values of the slip are not desirable because they will necessarily be accompanied by very low efficiencies. As another point deserving special attention, mention may be made of the fact that the efficiency varies but slowly when near its maximum value, and hence a moderate change in the slip may be allowed without seriously changing the efficiency. The slip might thus, for example, be considerably increased with a corresponding reduction in size of propeller and with a relatively small sacrifice in efficiency. It must not be forgotten, as before noted, that Figs. 1 - 3 and the accompanying remarks relate to the *true* slip, which is usually from 5 per cent to 15 per cent greater than the apparent.

NEGATIVE SLIP.

Perhaps no feature of the present subject has excited at one time and another more discussion than that of *negative slip*. This has been due in great measure to a lack of understanding of the phenomenon really in question, as well, doubtless, as to errors in data and measurement.

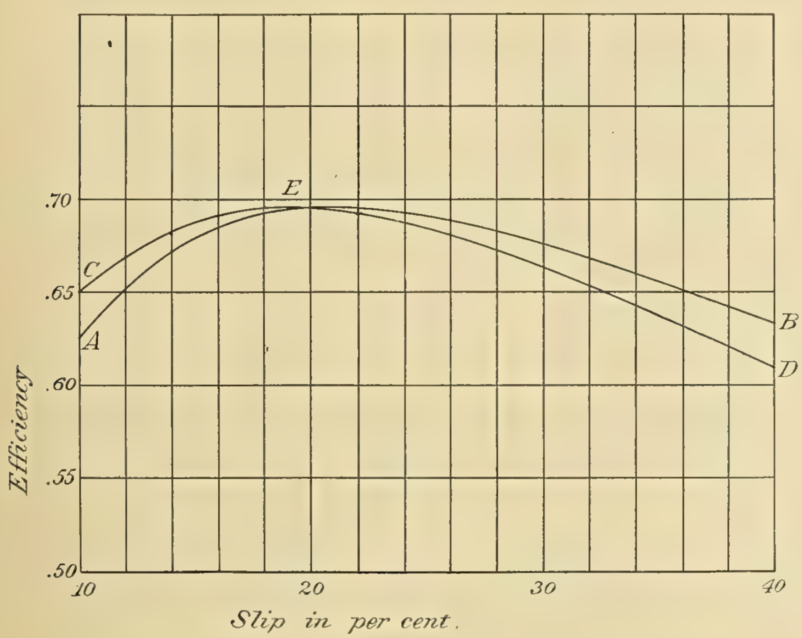


Fig. 3.

In the first place, it should be clearly understood that when reports of negative slip have been made, that it is the apparent and not the true slip which is in question. Failure to appreciate this lies at the root of most of the misunderstanding on the subject. The question is then simply, under what circumstances might we expect an apparent slip of zero or negative value? Remembering the relation between these quantities as expressed in (2) it may be readily seen that this will be the case when the true slip is equal to or less than the wake. If, therefore, the circumstances snould be such that the true slip were quite small or the wake quite large, we might expect a negative apparent slip, not as anything remarkable or astonishing, but as a simple and natural result of the relations between the true slip and the wake. We have already seen that size of propeller and slip are mutually interchangeable, and in fact within limits a propeller may be designed to propel a given ship with any specifieu value of the true slip. If, therefore, the propeller is of appropriate diameter and revolutions, the true slip may be reduced to a small value such as 8 or 10 per cent, and with an ordinary value of the wake for single screw ships we should expect in such case a negative *apparent* slip.

As indicated by the curves of Fig. 3, however, the efficiency at such small values of the slip is very poor, so that it is always undesirable to work under these circumstances, and it may therefore be accepted as a general rule that a negative apparent slip always means a very inefficient performance.

Let it be understood, then, that negative slip always refers to apparent and not to true slip, and that there is nothing in the least mysterious or remarkable in the appearance of such a result under the proper circumstances. Again, there has often been great uncertainty in the proper measurement of pitch and in the determination of slip, especially in the case of propellers with variable pitch. As discussed in the foregoing, a mean may be taken in various ways, and there is no generally accepted method. Many cases of reported negative slip may be thus due in part or in whole to errors in measurement, or to the lack of a proper basis for the reduction of variable pitch to a mean value. Again, the influence of the rounded back on the performance of the blade, and especially on the question of its effective pitch, is a subject not yet worked out. But a full discussion of these phases of the question is beyond our present limits. It is enough to remember that, basing our ideas of pitch and slip simply on the geometrical measurement of the driving face, there is no reason under proper circumstances, as described here, why the apparent slip should not become zero or even negative in value. If it appears as an objection that the ship goes faster than the propeller, or that in some way the conservation of energy is violated, it should be clearly understood that negative apparent slip arises wholly from the existence of a wake, and that the performance is fully paid for at the engine and at a higher rate than would be the case were the slip greater in value.

The reason for the practical disappearance of negative slip under modern conditions is that propellers are rarely so large or so designed otherwise as to give the necessary thrust with a true slip as small as 8 or 10 per cent. Instead, such values as 20 to 25 or 30 per cent are more common, giving values of from 10 to 20 or 25 per cent for the apparent slip.

SPECIAL GOVERNMENT VESSELS—THE ARMY TRANSPORT "GRANT" AND SISTER SHIPS.

BY WILLIAM A. FAIRBURN.

Among the vessels secured by the War Department during the progress of the Hispano-American war for the transport of troops was the entire fleet of first-class ocean steamships of the intermediate type owned by the Atlantic Transport Line. These vessels were purchased outright, and at the close of hostilities, when the Government decided to retain a number of vessels in permanent service as transports, the former Atlantic liners were included among the vessels so selected.

The fleet purchased included seven modern steel vessels which had been in the London and New York trade. Of these, five are sister ships, viz., Mobile, Mohawk, Massachusetts, Manitoba and Minnewaska, and the other two smaller vessels are respectively named Mississippi and Michigan. These ships are comparatively new, and all were built at the yard of Harland & Wolff, at Belfast, Ireland. When the decision to retain the vessels permanently in service as transports was reached contracts were awarded to various shipbuilding firms for the rebuilding and refitting of the vessels of the Mobile class. Although the contract prices for this work vary from $83,000 to about $100,000, yet the total amount of work done on these vessels, including all machinery repairs and hull extras, cannot fall short of $130,000 per vessel. The Wm. Cramp & Sons Ship and Engine Building Company, of Philadelphia, Pa., have rebuilt the Mobile. The Bath Iron Works, Ltd., of Bath, Me., have completed the work on the Mohawk. J. N. Robins Co., of the Erie Basin Dry Docks, Brooklyn, N. Y., have repaired the Massachusetts, and the Newport News Shipbuilding and Dry Dock Company, of Newport News, Va., secured the order for rebuilding the Manitoba. The contract for refitting the Minnewaska at the time of writing has not been awarded. These five vessels being sister ships are practically all alike and all have been similarly refitted and rebuilt, so that a description of any one of the completed vessels will serve for all.

The service maintained by the Atlantic Transport Line with this fleet of steamers included passengers, cargo and live stock, and an extensive trade was also done in dressed beef, carried in refrigerating chambers. The passenger accommodation on each ship was very limited in extent, and there was only one class (cabin), each vessel having accommodation for fifty-two first class passengers in the bridge house amidships. In a few months a great change has been wrought in these vessels, and the not over-clean cattle steamers of the Atlantic Transport Line have now been converted into handsome, efficient transports, clean, staunch and pleasant to inspect and live on. And yet one must remember that a thorough cleaning and painting is responsible for a great deal of this change, and as cattle steamers these vessels of the Atlantic Transport Line were just as capable of battling with the elements and were just as efficient and successful in the work for which they were designed and built as they are now as United States transports.

GENERAL CHARACTERISTICS.

The principal dimensions of these vessels are:

Length over all	460 ft.
Length between perpendiculars	445 ft.
Beam	49 ft.
Moulded depth at side to spar deck	41 ft. 6 in.
Moulded depth at side to main deck	34 ft.

They are steel, spar-decked, twin-screw steamers with four decks, viz., spar, main, 'tween and orlop. As cattle steamers the spar deck was portable at the four main hatches and cargo ports. A bridge deck amidships was uncovered and served as the passengers' promenade deck; the chart house and bridge being at the forward end. The tonnage of these vessels while engaged in merchant service was:

Gross tonnage	5,780 tons.
Net tonnage	3,725 tons.
Under deck tonnage	5,285 tons.

At a draught of 26 ft. they carried a little over 7,200 tons dead weight, and their light draught, with water in boilers, steam up, but no cargo, coal, water or stores, was about 12 ft. 3 in. The freeboard assigned these vessels, measured from the statutory deck line, was: Summer freeboard, 8 ft.; Winter freeboard, 8 ft. 6 in.; Winter North Atlantic, 9 ft.; and in Fresh Water and Indian Summer, 7 ft. 6 in.

As transports their light draught is about 13 ft. and the displacement about 5,400 tons. When loaded to 15 ft. draught the displacement is 6,450 tons; at 20 ft. draught it is 9,000 tons; and at the extreme load draught of 26 ft. the displacement is about 12,200 tons.

These vessels have a double bottom extending from the forward collision bulkhead as far aft as is practicable, and there is also a trimming tank at each end of the vessel. The total capacity of the double bottom is 1,100 tons of water, and the total capacity of the two peak trimming tanks is about 125 tons. The double bottom is divided up into seven tanks, fore and aft, the two under the machinery carrying together 217 tons of fresh water. The three under the forward holds carry collectively 600 tons of sea water, and the two under the aft holds have a carrying capacity of 283 tons of sea water. Fresh water can now be carried in all the tanks of the double bottom. The holds of these vessels, i. e., all the space up to the orlop or lowest continuous deck, will be used for cargo, stores, coal and munitions of war, whichever the special circumstances demand. The capacity of these hold spaces is 149,000 cu. ft. The transports have also eight watertight complete transverse bulkheads, and therefore the hold spaces and all the 'tween-deck living spaces up to the main deck are divided into five watertight compartments. By means of watertight doors one can walk from the forward collision bulkhead to the after peak bulkhead on all the decks except the orlop, without any obstruction, provided the coal bunkers are not full. This may be a great convenience, but if any serious accident befall these vessels when loaded there is the possibility of this convenience leading to a most disastrous end. The troops are berthed on the 'tween and orlop decks; therefore these two decks are now known as the upper and lower berthing decks. The main deck is designated the mess deck, and here, forward and aft, the soldiers will be fed, while 'midship the majority of the ship's complement will mess. The spar deck is the soldiers' weather or promenade deck, though considerable lounging will probably be done on the main or mess deck, as four large double and two single swinging side ports on each side of the ship—which will be always open in good weather—will make both the air and light on this deck very agreeable.

The cubical capacity of the orlop deck berthing space is 73,400 cu. ft., and that of the 'tween-deck berthing space 103,250 cu. ft. The store rooms and the magazine below the main deck have a capacity of 4,000 cu. ft., excluding all the refrigerating spaces. The cold storage rooms or refrigerating spaces are located just abaft the engine room on the orlop deck and on a flat below it. The capacity of these spaces is 32,250 cu. ft. Pulverized charcoal is used for the insulation of all these spaces.

These vessels had originally seven cargo hatches, excluding the meat hatch, but the aft hatch and the meat hatch have been closed up in rebuilding. There are now six hatches from the spar deck to the hold: No. 1 is about 10 ft. by 12 ft. 6 in., No. 2 is 21 ft. by 13 ft. 6 in., No. 3 is 15 ft. by 13 ft., No. 4 is 9 ft. by 10 ft., No. 5 is 14 ft. by 12 ft. and No. 6 is 12 ft. square. The first dimension in each case is the fore and aft dimension. Four of these hatches are forward of the bridge house and two are abaft it. A large double drum steam winch is located at each hatch. Large wooden portable booby hatches are placed on each hatch on the spar or weather deck. These boobies occupy in area on an average about one-half of the hatch space and from them two pairs of 48 in. portable stairs with rubber treads lead to the decks below. There is full head room in all of these booby hatches. Galvanized iron pipe railings are worked around all the hatches on the mess and berthing decks and similar railings are placed on all the stairs. The parts of the hatches on the spar deck not occupied by the boobies are fitted with the usual hatch covers and tarpaulins. Galvanized close-link chain (5-16 in.), with a suitable number of portable wrought iron stanchions, which slip over the hatch bar irons, form a satisfactory life line around the spar deck hatches when the boobies and hatch covers are removed for ventilation, etc. The booby hatches have been made portable and they are arranged so as to stow on the skid beams. A small booby hatch is located forward and a similar one aft, so as to give access to all the spaces below, when the stairs are all removed from the main hatches and the cargo is being taken on board.

Each vessel has four steel pole masts, all with a rake of 1 3-4 in. per foot. The trucks of the fore, main and mizzen masts are 142 ft. above the bottom of keel, while that of the jigger mast is 127 ft. There are in all twelve large cargo derricks or booms, the average size of these being 45 ft. long and 12 1-2 in. dia. The appliances for the rapid handling, loading and discharging of cargo are such as are found only on modern first-class money-earning vessels.

These transports have eleven boats and eight metallic life rafts each. Seven of the boats are 27 ft. life boats, with a beam of 8 ft. and a depth of 3 ft. 4 in. Two of the boats are 20 ft. working boats and the other two are 30 ft. steam launches, built by the Gas Engine and Power Company and Seabury Consolidated, of New York. Three of the 27 ft. life boats and the two 30 ft. launches are carried on heavy wooden skid beams above the spar deck. The remainder of the boats are carried on the hurricane deck amidship and the life rafts are carried on the top of the spar deck lavatory aft. Each vessel is fitted with three large wooden side ladders and eight rope Jacob's ladders with wooden treads, all of which lead from the weather deck to the high water line.

ACCOMMODATION OF SHIP'S COMPLEMENT.

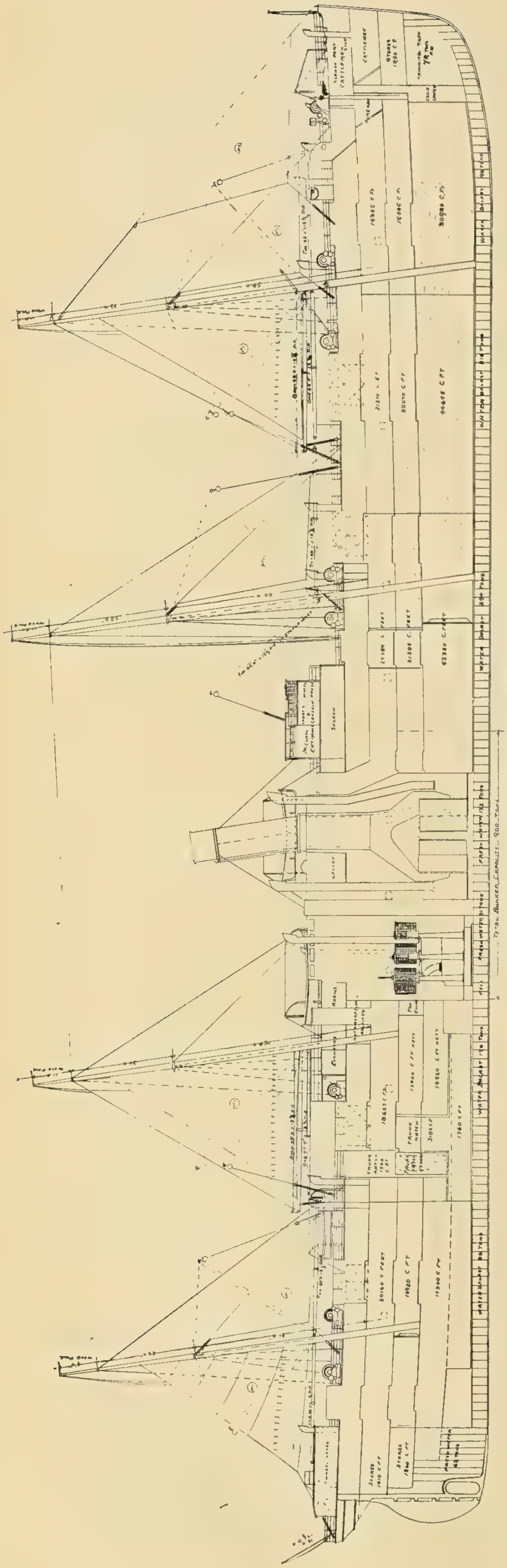
The seamen's quarters are located forward, there being a room on the main deck starboard side with eighteen berths and one on the 'tween deck at the extreme forward end with sixteen berths. The total number of berths for seamen is therefore thirty-four. The firemen and coal passers have a room on the main deck forward, port side, which contains fourteen berths, and also one on the 'tween deck just abaft the seamen's quarters containing twenty berths; the total number of firemen and coal passers' berths being thirty-four. All these rooms are airy, well lighted and commodious. The oilers and water tenders have a room on the main deck forward, starboard side, containing ten berths. A large room on the port side of this deck with twelve berths is used by the mess boys. Just forward of it is a room with six berths for the scullions. A room with four berths for the ship's quartermasters or wheelmen, and rooms with two berths each for the carpenters, boatswains and donkeymen, are located on the main deck, port side, between the scullions' room and the firemen's quarters.

The ship's officers' accommodation is located in the after part of the bridge house. Staterooms are here fitted for the first officer, second officer, third and fourth officers, steward, doctor, chief engineer, first assistant engineer, second and third engineers, fourth and fifth engineers, sixth engineer, electrician and refrigerating engineer, and two cooks, and a four-berth room is used by the bakers and assistant stewards. The officers' mess room is located on this deck just abaft the engine room casing. The captain's room is located alongside the chart house on the bridge deck forward, and the top of these two rooms forms part of the flying bridge which runs out to the side of the vessel.

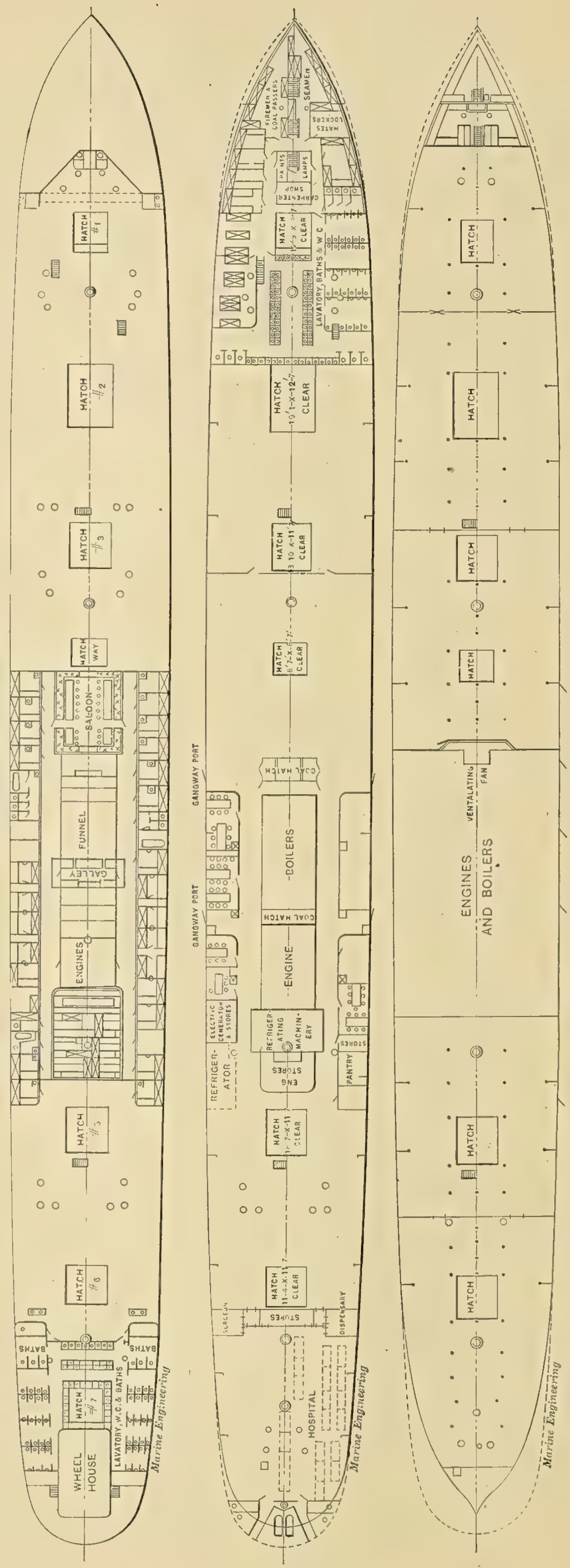
TROOPS' BERTHING ACCOMMODATION.

On the 'tween decks there are five compartments used for berthing the soldiers. Three are forward of the machinery space and two are abaft it. On the orlop deck there are only four compartments used for this purpose, as compartment No. 5 is part of the refrigerating space. The following figures give the number of berths in each space on the transport Mohawk:

The total number of berths on this vessel used for the accommodation of troops is therefore 2,118. This figure may vary a little from the other vessels, as the



INBOARD PROFILE S.S. MOHAWK.



DECK PLANS TRANSPORT GRANT.

INBOARD PROFILE AND DECK PLANS OF THE U. S. TWIN-SCREW ARMY TRANSPORT GRANT, FORMERLY THE ATLANTIC TRANSPORT LINE S.S. MOHAWK.

UNITED STATES ARMY TRANSPORT GRANT, READY TO START FOR MANILA WITH THE 4TH AND 17TH U. S. INFANTRY ON BOARD.

ATLANTIC TRANSPORT LINER MANITOBA BEFORE RECONSTRUCTION AS A UNITED STATES ARMY TRANSPORT.—OTHER TRANSPORTS WERE SIMILAR IN APPEARANCE.

location of web frames is not the same on all these ships, and the Mobile has smaller berths than her sisters. The total number of berths on the Mobile is 2,136, but the larger berths, as fitted in the Mohawk, have been adopted as the standard. These berths are neatly made of galvanized pipe, three high. They are portable, and the stanchions fit into a flush socket in the deck—a brass fitting tapped into the deck from the under side—and into a hole in a heavy wood batten located on the deck above. The lowest berth is

No. of Compartment.	'Tween Deck.	Orlop Deck.
1	144	180
2	276	276
3	264	264
4	249	...
5	267	198
Total	1,200	918

about 8 in. above the deck and the others are 24 in. apart. The single berths are 77 in. by 25 in. centers. The double berths are 77 in. by 50 in. centers, and the double berths in way of stanchions are 53 in. wide. The decks are all steel in the troops' berthing spaces and they are not sheathed with wood, neither are they covered with linoleum. Wood gratings in the passage ways between the berths are being tried as an experiment, and if found satisfactory they will probably be adapted throughout. Some covering on the iron deck is absolutely essential for comfort, and cork, carpet, linoleum or wood should certainly be adopted.

REGIMENTAL OFFICERS' ACCOMMODATION.

There are twenty-four large, pleasant staterooms for regimental officers on the bridge deck in a new wooden house built around the engine and fire room hatches. There are also twenty-one roomy staterooms on the spar deck in the bridge house, which were formerly used for the accommodation of the passengers. All of these rooms have two berths each, a large, full-sized lounge or upholstered seat, washbowl and the usual stateroom furnishings and fittings. This makes berthing accommodation for ninety officers, and if the seats are used as berths sleeping accommodation can be provided for 137 regimental officers, for in two of the largest rooms the back of the seats will swing and form a berth. The quartermaster's office is in the forward part of the house on the bridge deck just abaft the captain's rooms; it contains desks, writing tables, bookcases, lockers, a large typewriter, copying press, etc. The quartermaster's stateroom and the rooms for his clerks are also located in this house, well furnished and complete in all their appointments.

TROOPS' MESS ACCOMMODATION.

The mess tables on the Mohawk—and her sister ships are fitted in a very similar manner—are of ash, 1 1-4 in. thick, with wrought iron legs and braces. They are 96 in. long and 27 in. wide. Each table has two ash benches, 18 in. high, 96 in. long and 10 in. wide. On the forward mess deck twenty-five tables are fitted, with a total seating capacity of 250 men. On the aft mess deck there are fifty-five tables, which will seat 550 men. The total number of mess tables is therefore eighty, and the total seating accommodation is for 800 men. These mess tables stow in bails overhead between the beams and in racks on the bulkheads.

REGIMENTAL OFFICERS' DINING SALOON.

The regimental officers use the old ship's cabin or main saloon as their dining room. In this saloon there is seating accommodation for about forty-eight people, but the tables are arranged differently on the different vessels. This room is elegantly furnished. A piano is located at the aft end, and the room has been practically unchanged, the upholstering and furnishings being the same as they were when the room was used for the accommodation of cabin passengers in the transatlantic trade.

MESS ROOMS FOR THE SHIP'S COMPLEMENT.

The ship's officers' mess room is in the after part of the bridge house, but all the petty officers and crew mess in rooms on the main deck amidship abreast the machinery casing. The forward mess room on the port side is for the seamen. Here there are two tables and twelve stools. Aft of this room is the firemen and coal passers' mess room, with three tables and sixteen stools. Then comes the petty officers' mess room, with one table and six stools, and aft of all is the oilers and water tenders' mess room, with one table and six stools. On the starboard side is the stewards' mess room, with two tables and thirteen stools. The total number of tables in the rooms on the mess deck 'midship for the ship's complement is therefore nine, and the seating capacity is fifty-three men.

HOSPITAL BAY.

The hospital bay is located on the main deck aft. It extends from the aft mess space to the extreme aft end of the ship. About thirty double beds are located in the hospital, which is 57 ft. long and 38 ft. wide. In the lazarette are bath rooms and water closets, opening from the hospital, and at the forward end is the dispensary, doctor's office, kitchen and store room, and two nurses' rooms. The floor of this room is covered with cork carpet, and the hospital is well lighted and ventilated, a large trunk hatch, 10 ft. square, fitted with a skylight on top, leading from the deck above.

LAVATORIES, WATER CLOSETS AND BATH ROOMS.

One of the most important features of a successful transport is the fitting of an adequate number of wash bowls and water closets. In these vessels this essential has been given great thought, and the result is most gratifying. A large lavatory is fitted forward, between the crew's quarters and the soldiers' forward mess room on the main deck. The floor is covered with asphaltum and cement panels, and here thirty water closets with flushometer valves, fifteen urinals, six shower baths and sixty-one wash bowls are located to good advantage. The aft lavatory is on the spar deck, just forward of the wheel house. This is fitted in a similar manner to the forward lavatory, and in it are located twenty-eight water closets, thirty urinals, thirty-three wash bowls and eight shower baths, two of the latter being in separate rooms for the officers. Other water closets, tub baths and wash bowls are located throughout the vessel where most desirable. Large mirrors are placed over all the wash bowls in both lavatories, and these rooms have a rich, expensive appearance quite different from what one would expect on board an army transport.

GALLIES AND PANTRIES.

The coal galley on these vessels is about 21 ft. by 8 ft. 6 in. It is fitted complete with ovens and ranges of ample capacity. The steam galley is a very large, commodious room on the main deck, starboard side, amidship. It is 35 ft. long and 9 ft. wide, and is fitted with eight large kettles and two urns. A scullery about 14 ft. long and 9 ft. wide is fitted just aft of the steam galley, and a large pantry with about 100 sq. ft. of floor space is fitted just aft of the main saloon or officers' dining saloon. This pantry is fitted with an 8 ft. steam table, two urns, dressers, ice box, etc. In the hospital kitchen aft there are two cereal cookers, a 5 ft. steam table and two urns. A small room opens from the ship's officers' mess room, for washing dishes, and a room is used for a similar purpose just abaft the saloon pantry. A large bakery is located in the bridge house on the port side amidship, well equipped with bins, lockers and an electric kneading machine. Each vessel has large linen and store rooms for the steward's department.

VENTILATION.

Each vessel is fitted with a very complete ventilating system. Four large steam fans are located on the spar deck. Air heaters, coolers and cleansers are provided. Galvanized iron ducts rectangular in section deliver air to all spaces occupied by troops, hospital, gallies, saloon, pantries, mess rooms, forecastle and all sleeping rooms except those on the bridge deck.

ELECTRIC PLANT, ETC.

The vessels are beautifully illuminated, and at night the living spaces are as light as day. Each vessel has 600 16 C. P. electric lights. The old British electric generators have been rewound for 110 volts, and the vessels have been rewired throughout and converted to the double wire system. A new dynamo and engine has been furnished by the U. S. Government, and this is located in a new electric generating and store room on the main deck port side amidship. A search light has been placed on a platform built above the bridge forward. All the spaces below the weather deck are painted white. A first class distilling plant has been fitted, and large tanks with brine coils are provided for troops' cold, fresh drinking water.

U. S. TRANSPORT GRANT—SHOWING TRIPLE-TIER BERTHING ARRANGEMENTS.

FITTINGS IN GENERAL.

Awnings of No. 4 cotton duck have been provided to cover the entire length of the ship. These awnings are placed about 4 ft. above the hurricane deck and also over the skid beams.

The outfit of these vessels, boats, rafts, life preservers, buckets, also fire connections, hose, etc., are supposed to cover all the requirements of the U. S. steamboat inspection rules for passenger ships.

Musket racks are fitted in all the troops' berthing spaces, with a total capacity equal to the number of berths. These racks have a locking device, and they are placed above a rectangular air duct at the sides of the vessel.

PROPELLING MACHINERY.

The propelling machinery of these vessels is of the usual type fitted in vessels of this class at the time these vessels were constructed. The total length occupied by the machinery is 80 ft., and of this space 25 ft. is devoted to the engine room. Aft of the engine room is a recess 10 ft. long and about 8 ft. high and the width of the engine room, in which the thrust bearings and two old dynamos are located.

Each vessel is propelled by twin screws with triple-expansion engines and three cylinders, each working on its own crank. The cylinders are not directly connected to each other, and the high pressure is located forward and the low pressure aft. The cylinders are 22 1-2 in., 36 1-2 in. and 60 in. dia., with a stroke of 48 in. The piston-rods of the intermediate and low-pressure cylinders extend up through the cylinder head and form tail rods. The high pressure cylinder has a piston valve, and the others are fitted with slide valves.

The hull of the vessel is built out to the shaft struts aft.

Steam is supplied by two double-ended and two single-ended Scotch boilers at 175 lb. working pressure. On their trial trips in the light condition these vessels are reported to have attained a speed of 13 to 13 3-4 knots per hour, but at the present time in actual service the speed of these vessels will vary from 10 knots loaded to about 12 knots light. The piston speed is very low, the maximum being only about 550 ft., and at this speed the two engines together will indicate about 3,000 I. H. P. In actual service 60 revolutions and 480 ft. piston speed is all that can be obtained. The auxiliaries on these ships are so numerous, and such great steam consumers, that fully one-fifth of the boiler power will at times be required for the auxiliaries. The coal bunker capacity is 900 tons, and the vessels burn about 60 tons of coal per day at full speed.

The machinery of all of these vessels is not in first-class condition, but probably all the defects will in time be remedied, and careful management and running will prevent a repetition of the condition of affairs which existed at the time these vessels were sent to private shipbuilding yards to be rebuilt and refitted.

The War Department has recently decided to name these vessels after famous generals, and the "Mohawk" will now be known as the "Grant," the "Mobile" will be called the "Sherman," the "Massachusetts" will be renamed the "Sheridan," and the "Manitoba" and "Minnewaska" will probably be called the "Logan" and "Thomas" respectively.

AN INLAND SHIPYARD.—SITUATED ON THE JAMES RIVER AT RICHMOND, VA.

Nearly three hundred years ago Captain Christopher Newport, under orders from the London Company, sailed up the James river as far as Richmond, and there located, as the old chronicle has it, safe from the Spaniards. A few months ago, at the outbreak of the war, the Government had under consideration the building of ten gunboats, at the same place, to be safe from the same Spaniards. Thus the verdict of the centuries points to Richmond as a place inaccessible to a hostile sea force; and as for a land force, the difficulties of investing that city are well known.

The place is well situated for a shipyard; the James river has a depth sufficient, at present, for boats drawing 18 ft. of water, and the Government has commenced deepening it; eventually there will be 22 ft. at low and 25 1-2 ft. at high water, enough to float anything but the largest ships.

The torpedo boats now under construction are not the first efforts of Richmond in the direction of ship building. The Tredegar Iron Works, famous for its cannon, built vessels for the U. S. Navy before the war, and during the war several gunboats were built. At the time of the evacuation of the city the last gunboat fell into the hands of the Federal forces; it had been named the *Ladies' Gunboat*, and was built wholly from contributions of plate and jewelry given by the Southern women. After the war the Old Dominion Steamship Company built one ship there.

Modern marine work in Richmond dates from the construction of the engines of the U. S. battleship Texas by the Richmond Locomotive Works, under the supervision of William R. Trigg, who was president of the company at that time.

The magnitude of the undertaking attracted widespread attention, and the success of the engines was so great as to demonstrate once for all that the mechanical ability of the American people south of Mason and Dixon's line was equal to that of their brothers in the North.

The attention of the Government has been turned more than once toward Richmond as a place for building warships. In critical periods of the country's history, especially at the time of the Venezuelan trouble, its securely protected harbor and abundance of water, with free connection to the sea, were advantages that appealed directly to the understanding of members of the Government, and arrangements were actually in hand for the rapid construction of small gunboats.

The plan of the yard now in operation at Richmond has been matured, step by step, during many months, although to the people at large the yard's entrance into the torpedo boat competition was very unexpected and occasioned considerable surprise and discussion in shipbuilding circles.

The plant of the William R. Trigg Co. will eventually be very complete. With about 1,000 ft. of water front, it can handle almost any class of ship excepting the largest, and is also prepared to do, and will do, the best possible class of work. Eventually the falls of the James river are to be utilized for the generation of electricity, somewhat after the plan of the Niagara Falls Power Company, and as soon as this is completed the Trigg Company will use the power thus obtained, as is now done in the shipyard in Buffalo, N. Y.

The shipyard has a complete outfit of angle and plate tools, embodying the latest designs, fitted by the Hillis & Jones Co., of Wilmington, Del. The Chicago Pneumatic Tool Company has contracted to furnish all the necessary pneumatic tools for riveting, drilling and caulking, and will shortly have the plant in complete working order.

The machine shop is 375 ft. long by 100 ft. wide, with a large L, and is fitted with all the necessary tools, including many new ones from the best makers.

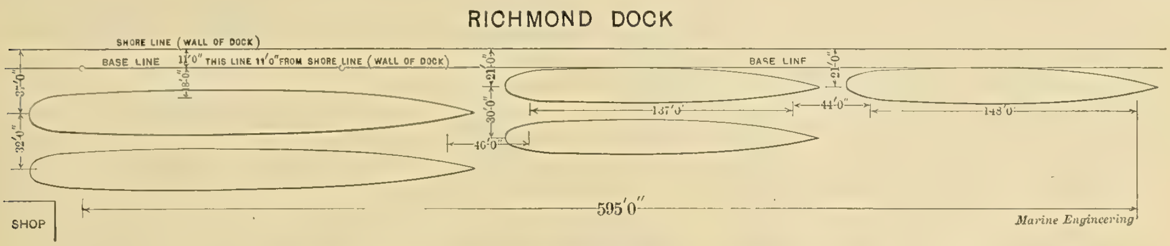
The brass foundry, pattern and cabinet shop and smith shop are well fitted to meet the sharpest competition.

After the torpedo boats are well under way the company will devote some attention to merchant work, but at present it does not care to undertake any but Government work, so that the present contracts will be finished on time.

The boats are to be launched sideways, as is the custom in river launching. The accompanying plan shows the general arrangement of the boats on the stocks. When the works are running under full load they will have about 500 men on the pay roll.

At the time that William R. Trigg submitted bids in his own name for these boats there was considerable opposition from the other builders, but the showing that he made in a few weeks convinced the Navy Department that the Trigg Company could fulfil its obligations, and its showing up to the present time, although working under the disadvantage of establishing a new yard, is such as to place it on a plane with older competitors.

The accompanying photographs show the present



LOCATION OF WAYS FOR TORPEDO BOATS IN TRIGG YARD.

VIEWS IN THE NEW TRIGG SHIPYARD AT RICHMOND, VA.

condition of the yard, and the energy with which this work has been conducted, as two months ago the space now occupied by the ship shed was a junk heap of old rails and ties.

William R. Trigg, the president, is aided by Lilburn T. Myers, vice-president. The superintending naval engineer, William Strother Smith, U. S. N., and the naval constructor, George H. Rock, U. S. N., are in charge of the Government end of the work.

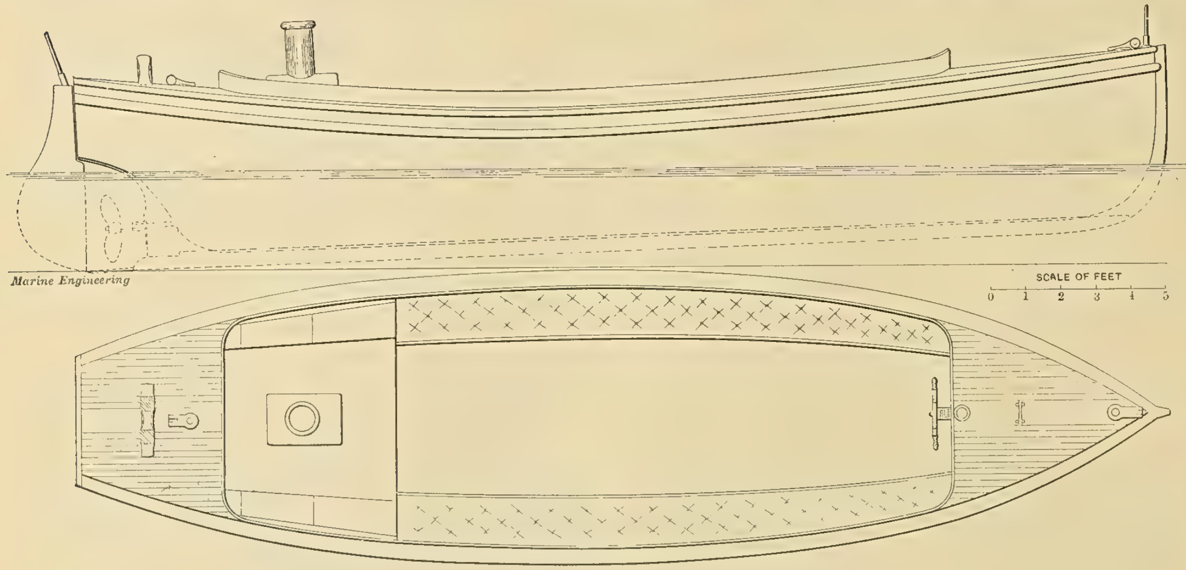
The company is building three torpedo boats, the Shubrick, Stockton and Thornton, and the two torpedo-boat destroyers Dale and Decatur. The torpedo boats are 175 ft. long, and are to make a speed of 26 knots at 165 tons displacement with 3,000 I. H. P. The destroyers are 245 ft. long, and must make a speed of 28 knots at a displacement of about 400 tons with 8,000 I. H. P. The contract prices are $129,750 and $260,000, respectively. The destroyers are to be finished in eighteen months and the torpedo boats in twelve months from the date of the signing of the contract.

Motor Boats for S.S. Paris.

As part of the equipment of the steamship Paris, of the American Line, when she leaves on a cruise to the West Indies, two alco-vapor launches will be carried. The design of these boats is shown in the accompanying engraving. As they are both alike the description of one will serve for the two.

The dimensions are: Length, 30 ft.; beam, 8 ft. The specifications call for a keel of white oak, sided, 3 in.; moulded at fore end 4 in., at stern 6 in.; stem of white oak, sided 3 in.; apron and deadwoods of white oak; stern post and overhang of quartered white oak; post sided 4 in.; timbers of white oak, spaced 11 in. centers, steam bent, sided 1 1-4 in.; moulded at head 1 1-2 in., at heel 2 1-2 in.; floor timbers moulded 3 in. at seat, sided 1 1-4 in.; keelson of oak, 3 in. by 3 in., copper bolted through keel; clamps of oak, 2 in. by 4 in., running entire length of hull and riveted through sheer strake, two on each side; planking of white cedar, to finish 3-4 in.; covering board and sheer strake of quartered oak; decking, 7-8 in. quartered oak, laid in 2 in. strips; 2 in. guard rail on lower edge of sheer-strake.

The boats will have open seats, and lockers will be provided in the motor room. A 12 horse power alco-vapor motor will be fitted and tank capacity for two barrels. A double tow post aft with crosshead will give facilities for towing the ordinary ship's boats for landing parties. Galvanized iron stanchions (2 in.) will be fitted fore and aft, with eyes in the heads, to go through the deck and step in the deadwood, and the deck plates for these will have screw caps to go in place when the stanchions are out. The fittings will include a steering wheel and chain gear, chocks and cleats, flag poles and sockets, strong hoisting eyes. A power whistle and kit of tools will also be provided. The hull will be finished with three coats of white paint, and the sheer strake, decks and inside of cockpit will be finished in natural color and given three coats of spar varnish.



OUTLINES OF MOTOR BOATS FOR S.S. PARIS OF AMERICAN LINE.

The new steamship Hamilton, for the Old Dominion Line, recently launched at the Roach yard in Chester, is a sister ship to the Princess Anne, described in our issue of August, 1897. Her dimensions are: Length, 332 ft.; beam, 42 ft.; depth, 27 ft.; tonnage, 3,200 tons. She is a single-screw vessel, and will be fitted with triple-expansion engines having cylinders 28 in., 44 in. and 73 in. dia. by 54 in. stroke. She will have three decks and four water-tight bulkheads, and will have accommodation for about 120 first-class passengers.

An order is reported placed by the Boston Tow Boat Co. with the Sparrows Point (Md.) yard for two steel colliers, each of about 5,000 tons capacity. The dimensions given are: Length, 345 ft.; beam, 47 ft.; depth, 28 ft. They will be fitted with triple-expansion engines and Scotch boilers.

CONSIDERATION OF THE INDICATOR AND ITS USES ON BOARD SHIP—II.*

BY R. W. JACK.

It has been accepted by many engineers, I think wrongly, that there are different qualities of steam, and in many of our text books those qualities are spoken of as the words imply, viz., saturated steam, dry saturated steam, superheated steam, etc. It would appear that the only object aimed at is that an expression may be found for an otherwise unaccountable percentage of water which interferes in our calculations. The terms are vague in the extreme, for if we admit that each appellation has a separate significance, there would be no limit to their number, because it may further be said that steam may contain water in suspension from only a trace up to a considerable proportion. It is at least much simpler and better adapted to our purpose to say that there is only one quality of steam, or rather there is only one term which we can consistently employ, viz., pure steam.

Steam, then, free from water or other impurity, and without undergoing a superheating process, is possessed of three distinct properties—pressure, volume, and temperature. One cannot change without affecting the other two. Each succeeding pressure has its corresponding volume and temperature; for instance, steam at a gauge pressure of 150 lb. per square inch has an invariable temperature of 370° F., and a specific volume of 173 compared with an equal weight of water. It will thus be seen that, given the pressure of steam at any point on an indicator diagram after cut-off or before exhaust opens, we may easily compute the volume and thereby the amount of water represented by the steam admitted to the cylinder for one stroke. The expansion curve becomes a most interesting study in this respect, for the steam line is influenced to some extent by the valve motion, by the rate of flow or the area of steam ports, and the temperature of piston and body of the cylinder. After cut-off has taken place, the steam which may have been condensed on entering will probably in part regain at some point its gaseous properties, and the equivalent weight of water will become a maximum. For the sake of simplicity, we are bound to suppose at this point that the engine is in good repair, that the valve and cylinder faces are steam tight, and that the piston is efficient for its purpose.

To find the maximum amount of water accounted for by the diagram, take the following specific example: Fig. 7 is a diagram taken from a high pressure engine whose cylinder is 3 in. diameter by 39 in. length of stroke. Take points x and y on each diagram just before exhaust opens. Those points, as a rule, will indicate the greatest quantity of steam since the water of condensation may possibly have reappeared as steam. Ascertain the pressures at x and y to scale, and also measure the portion of stroke completed at those points, say 35 in. The total volume of steam is therefore $= D^2 \times .7854 \times$ part of stroke completed + the clearance capacity at the end of the stroke. Let the clearance be 10 per cent of the space swept by the piston or $(D^2 \times .7854 \times \text{stroke}) \div 10$. We then have

Total volume of steam

$$= (23 \times 23 \times .7854 \times 35) + \left(\frac{23 \times 23 \times .7854 \times 39}{10}\right)$$

Worked out, this is shown to be 16162.27 cu. in. The pressure of steam at the point x is 110 lb. per square inch. By looking up a table of specific volumes we find that one unit of steam at this pressure, if condensed to water of the same temperature, occupies only $\frac{1}{220}$ of its previous volume. We must therefore divide the total volume of steam 16162.27 by 220 in order to find the equivalent volume of water, thus $16162.27 \div 220 = 73.46$ cu. in., nearly. The opposite diagram is treated in the same way. Those

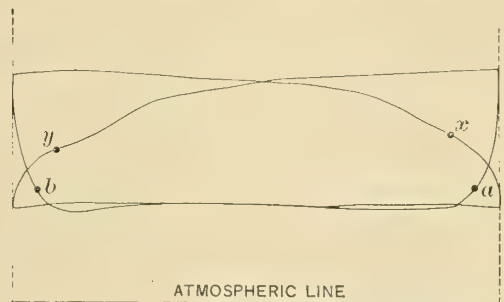


FIG. 7

operations may be further extended to either the I P or L P cylinders of a triple-expansion engine, and the deductions therefrom will scarcely require further explanation; but it should be pointed out that if we wish to find the quantity of water per revolution, per minute, or per horse power, it will be necessary to deduct from the foregoing result the weight of steam remaining in the cylinder after exhaust closes and compression begins. Points a and b may be taken in the same way on the compression curve, the steam at this pressure and volume correspondingly reduced to water and subtracted. The capacity of waste space at each end of cylinder we have supposed to be one-tenth of the space swept by the piston, which we found to be equal to 1620.36 cu. in., and the points a and b are taken in this case at 2 in. from the end of stroke, so that the total volume of steam remaining at pressures indicated by a and b is $1620.36 + (D^2 \times .7854 \times 2) = 1620.36 + 831 = 2451.36$ cu. in. The pressure of steam at the point a we find to be 100 lb. per square inch. Referring again to the table of specific volumes, we find that the relative volume of water is $\frac{1}{236}$, so that the equivalent volume of water remaining in the cylinder is $= \frac{2451.36}{236} = 10.4$ cu. in. nearly. Subtracting this from the first result we have $73.46 - 10.4 = 63.06$ cu. in. of water utilized each down stroke of the piston. The same operation is performed for the return or up-stroke, and their sum is the amount of water passing through the cylinder in the form of steam during each revolution.

To find the quantity of water accounted for by diagrams per minute or per hour, it is only necessary to multiply by the revolutions in the given time. The

* From a paper read before the Institution of Engineers and Shipbuilders at Hong Kong.

water used per I. H. P. per hour is equal to the total quantity per hour divided by the total I. H. P. If the weight of water be required, this again should be multiplied by .036, the weight of one cubic inch of water. We might also find the amount of work in foot-pounds, transmitted by each pound of steam, by dividing (I. H. P. × 33,000) by the weight of steam passing through the engines per minute. In the case we have considered, the combined I. H. P. of the three engines was 1,130, and the water shown by the H. P. diagram and per minute is 265.68 lb., then (1,130 × 33,000) ÷ 265.68 = 140,356 foot-pounds or units of work per pound weight of steam.

It has been attempted by various thermodynamists to obtain a modified equation which shall consider certain relations which are specially applicable to steam. Their calculations, however useful, have been based on assumptions which cannot possibly obtain in practice. They have supposed an ideal environment for the steam, such that it is incapable either of receiving of transmitting any portion of heat. This they have designated "adiabatic" expansion (literally meaning—nothing passing through), that is to say, the steam can neither impart its heat to its surroundings nor receive heat from any external source; but their calculations have taken into account those properties of steam which are strictly characteristic of such a medium. Stated shortly, it may be said that if a gas at a given volume, pressure, and temperature, by an addition or subtraction of dt of temperature could add or subtract equal increment of the volume and pressure, then $\frac{dv}{v}$ would be equal to $\frac{dp}{p}$. It requires more heat to add to volume at constant pressure than it does to add to pressure at constant volume, because in expanding at constant pressure an amount of external work is done requiring a certain amount of heat. The proportion of heat required is thus:

Heat required at constant pressure : heat required at constant volume :: $Kp : Kv$. But the specific heats at constant pressure (Kp) of gaseous bodies are known from direct experiment, and the specific heats at constant volume (Kv) may be calculated from Kp by deducting the thermodynamical equivalent of the work performed by the gas in doubling its volume. The increment of volume will therefore be less than the increment of pressure for a given increment of heat in inverse proportion to the specific heats, thus, $\frac{dv}{v} = \frac{dP\,kv}{K\,kp}$. Suppose a quantity of gas at volume V, and pressure P, to be expanding freely behind a piston, then if the change of volume $Kp\,\frac{dv}{v}$, combined with the change of pressure $Kv\,\frac{dp}{p}$, produces a change of temperature $d\,t$, that is, the sum of the changes produces a change $d\,t$ or conversely;

$$\text{then as } Kp\,\frac{dv}{v} + Kv\,\frac{dP}{P} = O \text{ (a minimum)}$$

$$\therefore Kp\,\frac{dv}{v} = Kv\,\frac{pP}{P}$$

$$\text{from which } dP = \frac{Kp}{Kp}\,P\,\frac{dv}{v}.$$

Without here introducing the mathematical proof of those relations, it may be useful merely to notice the results, for they are equally applicable in the general form to any gaseous body, viz.,

$$\frac{T^1}{T} = \left(\frac{V}{V^1}\right)\gamma\text{-}1 = \left(\frac{P^1}{P}\right)\frac{\gamma\text{-}1}{\gamma} = \frac{P^1\,V^1}{P\,V}.$$

Where T is the absolute temperature of any gas, i. e., the sensible temperature added to a constant 461° F. or 273° C., at a certain pressure P and volume V, while T_1 is the absolute temperature at any other pressure P_1 and volume V_1. The Greek letter γ (gamma) when used in this connection is understood to mean the relation $\frac{Kp}{Kv}$, and it is this value which is the main factor in the mathematical solution of the adiabatic curve.

Instead, therefore, of the constant number we obtain by simply multiplying the pressure and volume together ($P\ V$) we have as a constant the value $P\ V\ _\gamma$ where γ is the power to which V must be raised. Authorities have given us the values of γ—for dry saturated steam $\frac{17}{16}$, superheated or gaseous steam 1.3, and wet ordinary steam $\frac{10}{9}$; but even these values are empirical and the accuracy of any one of them mainly depends upon its selection. Let us take the case of ordinary or wet steam, as it is called, and see how the constant $P\ V\gamma$ or $P\ V^{\frac{10}{9}}$ may be applied to the construction of an expansion curve. In the case we have already considered, $P = 100$ and $V = 4$, $\therefore P\ V^{\frac{10}{9}} = 100 \times 4^{\frac{10}{9}}$. To raise 4 to the $\frac{10}{9}$ power we may make use of a table of logarithms, thus: $\log 4 = .60206 \times \frac{10}{9} = .66895 = \log 4.666$, $\therefore P\ V^{\frac{10}{9}} = 100 \times 4.666 = 466.6$. We have supposed that steam is carried $\frac{4}{10}$ of the stroke, and to find the pressures corresponding to volumes 5, 6, 7, 8, 9, and 10, we may place it in this form—

$$\left.\begin{array}{l} V = 5.\ 5^{\frac{10}{9}} = \log 5 \times \frac{10}{9} = .699 \\ \quad \times \frac{10}{9} = .776 = \log \text{ of } 5.98 \end{array}\right\} \therefore P_5 = \frac{466.6}{5.98} = 78.04\,lb.$$

$$\left.\begin{array}{l} V = 6.\ 6^{\frac{10}{9}} = \log 6 \times \frac{10}{9} = .7782 \\ \quad \times \frac{10}{9} = .8647 = \log \text{ of } 7.233 \end{array}\right\} \therefore P_6 = \frac{466.6}{7.323} = 63.7 \text{ ``}$$

$$\left.\begin{array}{l} V = 7.\ 7^{\frac{10}{9}} = \log 7 \times \frac{10}{9} = .8451 \\ \quad \times \frac{10}{9} = .939 = \log \text{ of } 8.69 \end{array}\right\} \therefore P_7 = \frac{466.6}{8.69} = 53.7 \text{ ``}$$

$$\left.\begin{array}{l} V = 8.\ 8^{\frac{10}{9}} = \log 8 \times \frac{10}{9} = .9031 \\ \quad \times \frac{10}{9} = .10034 = \log \text{ of } 10.08 \end{array}\right\} \therefore P_8 = \frac{466.6}{10.08} = 4.63 \text{ ``}$$

$$\left.\begin{array}{l} V = 9.\ 9^{\frac{10}{9}} = \log 9 \times \frac{10}{9} = .9542 \\ \quad \times \frac{10}{9} = 1.06 = \log \text{ of } 11.48 \end{array}\right\} \therefore P_9 = \frac{466.6}{11.48} = 40\ 7 \text{ ``}$$

$$\left.\begin{array}{l} V = 10.\ 10^{\frac{10}{9}} = \log 10 \times \frac{10}{9} = 1.000 \\ \quad \times \frac{10}{9} = 1.111 = \log \text{ of } 12.91 \end{array}\right\} \therefore P_{10} = \frac{466.6}{12.91} = 36.1 \text{ ``}$$

Those pressures as before are marked off to scale and the curve drawn through the points. Those are strictly mathematical solutions of the expansion curve, and the operations, though somewhat tedious, are absolutely necessary to an intelligent conception of the principles on which the graphic or geometrical solutions depend. To construct a hyperbolic or simple $P\ V$ curve by the latter method, let the actual indicator diagram Fig. 8 be taken to illustrate the method employed. This is taken from one end of a high-pressure engine. $A\ B$ is the perfect vacuum line drawn to scale 14.7 lb. below the atmospheric line $C\ D$. $A\ E$ represents the clearance in proportion to the volume of the cylinder $E\ B$. If a diagonal be drawn from A at an angle of 45°, or one-half the right angle $H\ A\ B$, then this will be the axis of every hyperbola having its origin at A, that is to say, corresponding portions of the curve on either side of it are exactly alike. Take any point F, preferably just before exhaust opens, and from F drop a perpendicular to the base $A\ B$ cutting in G. Divide $A\ G$ into any number of divisions (not necessarily equal) and erect perpendiculars through those points from the base $A\ B$. From A cut off $A\ J$ equal to $F\ G$ and draw $J\ I$ at right angles to the base $A\ B$. From J cut off $J\ I$ equal to $A\ G$. Then the point I will be another point in the hyperbolic curve, because pressure and volume being interchangeable quantities, the volume $A\ J \times$ the pressure $J\ I$ is made equal to the volume $A\ G \times$ the pressure $F\ G$. Draw H_{10} equal and parallel to the base line $A\ G$, then join A_2, A_3,

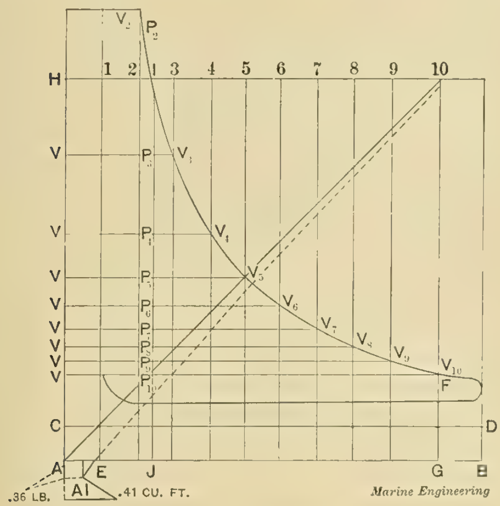


FIG. 8

A_4, A_5, A_6, A_7, A_8, A_9, and A_{10}, and where those lines cut the perpendicular $J\ I$ in P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, and P_{10}, those points will represent the pressures corresponding to their respective volumes VV_2, VV_3, VV_4, VV_5, VV_6, VV_7, VV_8, VV_9, VV_{10}. A curve drawn through the points V_2, V_3, etc., is an hyperbolic or isothermal curve, and is said to be the curve of ideal expansion. There is another curve by which the real expansion curve of an indicator diagram is often compared, viz., the saturation curve. Acording to Rankine, this may be worked out on the same lines as the example we have just considered, but that instead of a constant $V\ P\ \frac{10}{9}$ constant we are given $V\ P\ \frac{17}{16}$. As already observed, it is very desirable that we should be able to construct such a curve by the graphic method. It has been proposed by Fairbain and Tate as a substitute for Rankine's formula for the curve of saturated steam to employ the same method as is employed in the geometrical delineation of the hyperbolic curve, but that instead of making the origin of the axis as at A in Fig. 8, it is merely shifted by adding .36 lb. to the pressure, i. e., below the perfect vacuum line, and subtracting from the volume in cubic feet .41 cu. ft. In the diagram shown, Fig. 8, $A\ G$ is supposed to represent the volume in cubic feet of 1 lb. weight of steam at a pressure corresponding to $G\ F$. If the pressure $G\ F$ be 40 lb. absolute per square inch, then $A\ G$ will represent a volume of about 10.3 cu. ft., which is the space occupied by 1 lb. weight of steam at this pressure. With the point thus found we may proceed as before. The curve thus drawn approaches very nearly to Rankine's formula for saturated steam, $P\ V\ \frac{17}{16}$. The difference between this and the adiabatic curve is that in the latter a certain amount of water is present due to the performance of work, while in case of a saturation curve the steam is supposed to be free from water by the transmission of heat from a steam jacket or other source. But of all the theoretical curves that may be drawn, the hyperbola is the most important. It fulfils the law in the broadest sense, and is a standard by which all others may be compared.

It may be conceded that the application of the indicator in calculating the effective stresses on the transmitting parts of a reciprocating engine does not strictly come within the scope of this essay, but it may be well to point out the modifications which the diagram must undergo in order to present a true picture of the effects of converting the reciprocating motion of the piston to the rotational movement of the shaft when conveyed through the combination of piston and connecting rods and a crank. The indicator diagram is primarily a true measure of work as applied to the piston, and only the ultimate effects are necessary factors in such a calculation. It is immaterial, as far as the mere work is concerned or the behavior of the steam, whether the velocity of the piston be uniform throughout the stroke, whether the motion be uniformly accelerated or variably accelerated, the ultimate effect is in moving the piston a certain distance against a certain resistance. The absolute pressure or motive force varies at every point of the stroke after steam is cut off, and the total resistance (neglecting friction) is the sum of the absolute back pressure or resisting force added to the resistance of the crank pin through the center line of the conecting rod. The resistance due to back pressure is fairly uniform during the greater part of the stroke, but varies toward that extremity which includes the compressive curve, while the resistance of the crank pin to tangential motion varies with every angle which the conecting rod makes with the crank arm. In order to compare the force at work it will be necessary to present the laws upon which their magnitudes depend, and to state as clearly as possible the exact definition of the terms employed. All forces are comparative in their effects, and the laws regulating the motion of a falling body, under the attraction of the earth or under the influence of gravity, are taken to be true as regards the motion of a body under the influence of any other force. Velocity—is the speed of a body measured in relation to the distance it would fall in a unit of time if the force under which it has acquired that velocity ceased to act, and under the action of a uniform force it varies as the time and the acceleration. Acceleration—is the rate of change of velocity in a unit of time and varies directly as the force under which it is generated. Space—is the distance in units of length, in which a body acting under the influence of a uniform force acquires a certain velocity and varies as the acceleration and the square of the time. The laws relating to motion under the simple attractive force of the earth may be thus symbolically stated when the body starts from rest, if $v =$ terminal velocity, $t =$ units of time, $s =$ space passed over, and $g =$ acceleration due to gravity $=$ a force of 32 units. Then $v = gt$, $s = 1\text{-}2\ gt^2$ and $v^2 = 2gs$.

If, then, we suppose the crank pin to revolve with a uniform speed, that is, if it describes equal arcs of a circle in equal intervals of time, the distances that the piston moves from either extremity of its stroke will depend on the versed sines of the angles which the crank arm makes with the center line of the engine, and that which the connecting-rod makes with the same line of centers. In Fig. 9, let *D B a* be the crank circle, and *A B* any position of the crank. From *B*, with a distance equal to the length of the connecting-rod, cut the center line in *C*, and from *C* with the same radius describe the arc *B G*. From *B*, draw *B F* perpendicular to the center line and cutting it in *F*. It will thus be seen that the distance *D G* is equal to *E C*, that is, the distance which the piston has moved from the dead point *E*. But *D F* is the versed sine of the angle *D A B*, and *F G* is the versed sine of the angle *B C G*, therefore the total distance *D G* or *E C* is the sum of those versed sines in the first quadrant of a revolution and their difference in the second, measuring from the opposite extremity D_1. Now, in order to convert an ordinary indicator diagram from a measure of work to a diagram of pressures on the crank pin, not only the distance traveled by the piston from rest is necessary, but also the relative velocities or accelerations occurring at each interval of the stroke. The mean velocity of the piston may be represented by the distance it has traveled in any interval of time, but with a uniform rotation of the crank the angular motion is more convenient and is the equivalent of time.

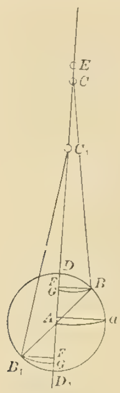


Fig. 9.

The spring cruise of the North Atlantic squadron was begun February 16, when the flagship New York, Rear-Admiral Sampson, and the battleship Indiana left the anchorage at Tompkinsville, S. I., for Bermuda. From there they will proceed to Havana, where several other vessels will join the squadron, and then to Cienfuegos, where they will arrive about March 5. Afterward the vessels will visit Guantanamo, and then this itinerary will be followed: Kingston, March 19 to 23; San Juan, Porto Rico, March 26 to 29; Martinique, March 31 to April 3; Barbados, April 4 to 7; Trinidad, April 8 to 13; La Guayra, April 15 to 18; Cartagena, April 21 to 24; and New York, May 3. The squadron will cover about 7,000 miles during the cruise.

Sinking of S.S. Germanic in Hudson River.

A peculiar accident happened to the White Star liner Germanic while alongside her pier in the North river, New York. She arrived from Liverpool after a stormy passage on Saturday, February 11, and the work of getting out her cargo was proceeded with rapidly, as she was billed to sail on her return voyage on the following Wednesday at noon. She was moored alongside the pier, which was on her port side, at a sufficient distance to permit the coal barges to come to the port as well as the starboard side. On Monday night, while the coal barges were alongside and the work of filling the bunkers was going on, and while the stevedores were at work in the hold, the vessel suddenly listed to starboard. An effort was made to right her by trimming, and then, according to present reports, she righted and immediately careened to port, toward the pier, with the result that her coaling ports on that side were submerged and she filled rapidly. As the water is shallow she soon reached bottom and began to settle in the mud. Wreckers were shortly put to work to pump out the vessel, and divers made repeated and unsuccessful efforts to close the ports. The views here published were taken the next day, but subsequently the vessel settled deeper, and in less than a week her hull was submerged at high tide as far forward as the forecastle.

Until an investigation is made it will not be possible to determine the exact cause of the mishap, which was apparently due to negligence. A lack of care in trimming the vessel in port was, probably, the chief cause, though contributory causes are said to have been the great masses of ice on the upper works and spars and the pressure of a strong wind blowing abeam.

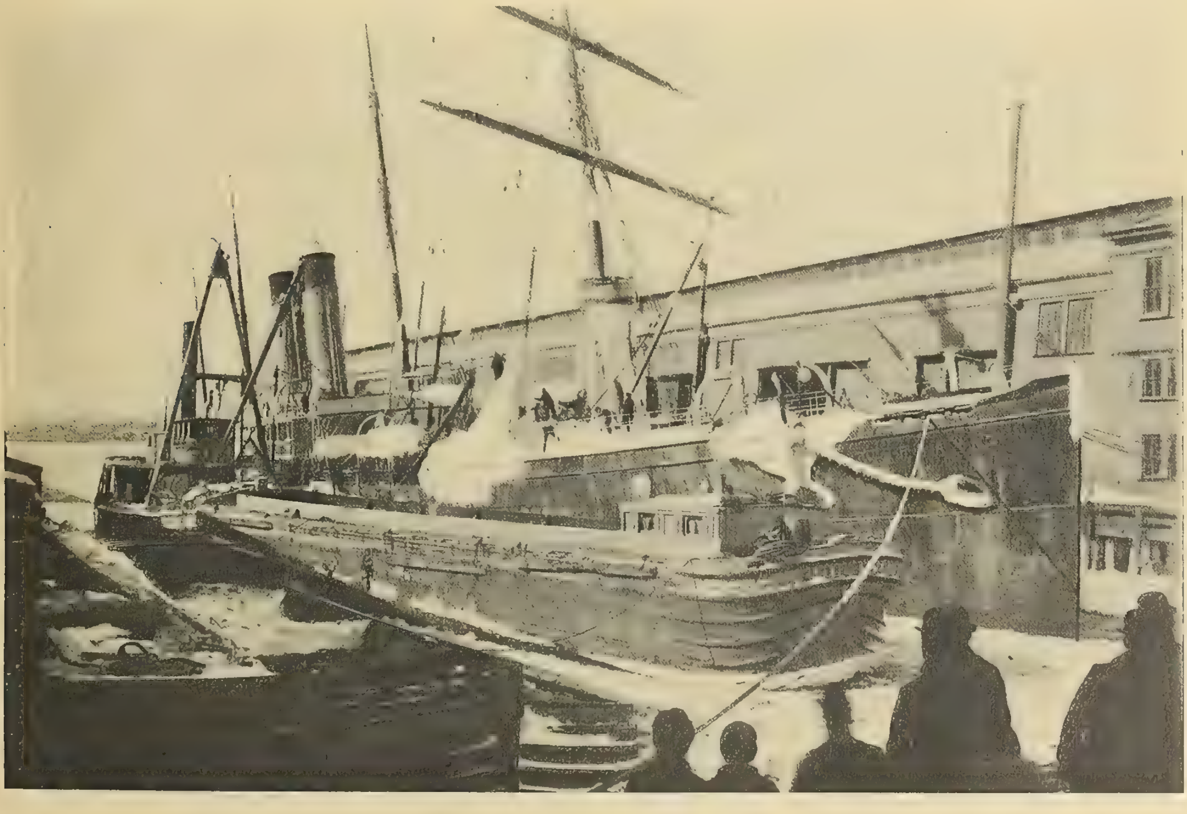
The sailing of the vessel has, of course, been indefinitely postponed, and the mails which she was to have carried out were forwarded to Boston to go East on the Dominion liner Canada. It is probable that thousands of dollars' worth of interior furnishings and finishings, and stores, have beeen rendered worthless by the flooding.

Other than a slight collision in the Mersey a few years ago this is, we believe, the first serious mishap that has befallen this vessel. She is one of the very oldest first-class liners in service to-day. With the Brittanic, her sister ship, she shares the reputation of being one of the most successful liners ever built. She is one of the original vessels of the White Star fleet, and was built in 1874 by Harland & Wolff at Belfast. Her dimensions are: Length, L. W. L., 455 ft.; beam, 45.2 ft.; and depth, from main deck, 33.7 ft. Her gross tonnage is 5,066 tons. She is an iron, single-screw vessel with four masts, and is fitted with eight bulkheads. She was originally fitted with compound engines and boilers carrying 75 lb. pressure. In 1895 new machinery was fitted at the builders' yard, including triple-expansion engines and Scotch boilers. At that time she had made nearly 300 round trips across the Atlantic, and had steamed about 1,700,000 miles and carried in all about 260,000 passengers.

Such mishaps, though rare, are not unknown. The most notable, perhaps, was that which occurred to the

STERN VIEW OF S.S. GERMANIC AFTER SHE HAD TOUCHED BOTTOM.

S.S. Austral, of the Orient line, in the freight and passenger trade between English and Australian ports. When coaling in Sydney harbor, several years ago, she suddenly turned turtle and sank.



BOW VIEW OF S.S. GERMANIC ALONGSIDE HER PIER IN NORTH RIVER, N. Y.

VIBRATIONS OF STEAMSHIPS AND METHODS OF BALANCING MARINE ENGINES—II.

BY C. H. PEABODY, B. Sc.

If the engine is placed aft in the run of the ship, as is customary on some lake steamers and some tank steamers, then the cylinders should be arranged in the reverse of the usual order—that is, the low pressure cylinder should be forward, as shown by Fig. 5. If the reciprocating parts have the proportions given by Schlick, then the low pressure cylinder should be aft of the node at a distance equal to five times the common interval between the cylinders.

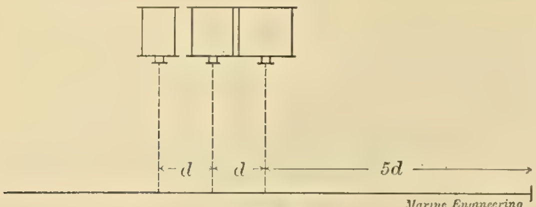


Fig. 5

A common practice on the Great Lakes is to put the high-pressure cylinder between the intermediate and the low pressure cylinders to save room, the low pressure cylinder being aft. If the low pressure cylinder should be placed forward, then, by an investigation similar to that given in the preceding note,* the location for the engine can be sought that will give least trouble from shaking.

Some triple-expansion engines have been built with two low-pressure cylinders, making four in all, arranged as shown by Fig. 6. The cranks for the high-pressure and the intermediate cylinders are opposite,

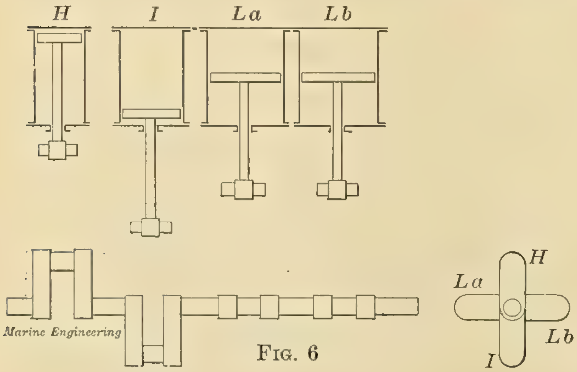


Fig. 6

as are also the cranks for the two low-pressure cylinders, but the two pairs of cranks are at 90 deg. The result is that the engine is very nearly in standing balance, and if deemed important that balance can readily be made complete by loading the high-pressure piston. The engine has, however, very considerable rocking couples at high speed, and consequently some engines which have been arranged in this way at the expense of considerable inconvenience in the design of the ship have proved disappointing, which is not surprising, since engines are more often near a node than a loop. If this arrangement of cylinders is chosen then the valve chests of the high-pressure cylinder should be in front and the valve chest for the intermediate cylinder should be turned aft so that these cylinders may be placed near together and so shorten the distance between their crank-pins and diminish the rocking couple that they will set up. In like manner the low-pressure cylinders should be placed back to back. The writer has seen this arrangement of valve chests just reversed, so that the two low-pressure cylinders had their valve chests between them, and consequently their cranks were widely separated, and being opposite, could set up a very considerable rocking couple. The high and intermediate cylinders were separated in a like manner though not to so wide a distance.

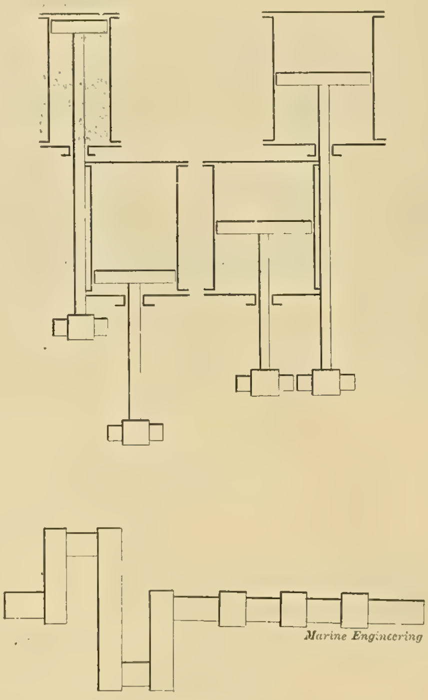


Fig. 7

Any four-cylinder engine, such as a quadruple-expansion engine, can be arranged in pairs and will then be nearly in standing balance and can readily have the balance made perfect if desired. It will of course have rocking couples, as has been pointed out.

In order to reduce the rocking couples to a very small amount Mr. Herreshoff has used the arrangement shown by Fig. 7 for a four-cylinder triple-expansion engine. The two low-pressure pistons are in exact standing balance and the high-pressure and intermediate pistons are very nearly in standing balance. The engine also has the distinct advantage that the thrust of the descending piston and the pull of the ascending piston of a pair are very nearly equal; there is therefore but a small amount of pressure on the main bearings, which therefore are little likely to give trouble from heating. Of course the arrangement shown by Fig. 6 has somewhat of the same effect, though less perfectly, as there is an intermediate bearing, which is required on account of the spring

* See note on p. 7 of February, 1898, issue of Marine Engineering.

of the intermediate crank shaft and the two intermediate crank cheeks. The chief objection to this claim is the difficulty of opening the two inside cylinders; for the engine represented by Fig. 7 there was a carefully worked out arrangement for taking down the lower cylinder head, which of course required the removal of the guides and the disengagement of the connecting-rod.

For some earlier engines of small size Mr. Herreshoff obtained the same result, that is, the removal of the intermediate bearing for a pair of opposite cranks, by shifting one of the two cylinders over to the port and the other to the starboard. When the cylinders do not have too large diameters in comparison with the stroke a shifting of their axes, or lines of dead points, about 15 deg. from the vertical will allow us to place them at the same height and still have them act on a pair of opposite cranks with only a continuous crank web between the crank-pins, as shown by Fig. 7. The cylinders will then appear as shown by Fig. 8. This arrangement of cylinders has beeen used on a large

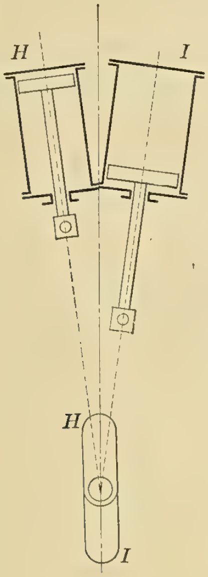


FIG. 8.

scale by Mr. Thornycroft for torpedo boats and torpedo-boat destroyers, and with very good results. The engines are indeed neither in standing nor in running balance, but the lack of balance, either standing or running, is not important for such engines and they do not produce excessive shaking. But when the diameter of the cylinder becomes greater than the stroke such an arrangement of the cylinders is likely to throw their axes 30 deg. out of the perpendicular and to lead to very undesirable proportions and arrangements of details, to say nothing of the fact that they will be far from balanced either when standing or when running.

Having considered the cause of vibrations of a steamship, and the effects that various arrangements of engine cylinders and cranks may have to aggravate or ameliorate the evil, let us investigate the methods that have been proposed for balancing engines and thus avoiding vibrations. The ill effects of the accelerating forces acting on the pistons of an engine were earliest felt on locomotives with outside cylinders as commonly arranged in America. The cranks are of course set at 90 deg., to insure certainty of control in starting and stopping, and consequently the piston on the right-hand side is at the middle of its stroke when the left-hand piston is starting at the beginning of its stroke. The right-hand piston is at its highest speed and there is no accelerating or retarding force acting on it, but there is a large accelerating force required to start the left-hand piston, which tends to slew the locomotive sideways on the track. Four times in each revolution such a slewing of the locomotive occurs, first one way and then the other, which tends to throw the locomotive off the track. To overcome this difficulty balance weights are cast between the spokes of the driver wheels, which are intended to counterbalance the accelerating forces acting on the reciprocating parts, i. e., the piston, piston-rod, crosshead, connecting-rod and side-bar. It is not necessary to go into the details of this method of balancing nor to point out its defects further than to call attention to the fact that the counterweights are always affected by a constant centrifugal force when the engine is running at a constant speed. This centrifugal force can be made to give a very good balance of the reciprocating parts when they are at the end of the stroke, but when those parts are at the middle of their stroke then the centrifugal force acting on the counterweight is entirely unbalanced. When the counterweight is down, between the driver axle and the track, the centrifugal force produces an added pressure of the driver wheel on the track in excess of the weight carried by that wheel when the locomotive is at rest. When the counterweight is up it tends to lift the wheel off the track. Consequently the counterweights produce a rocking of the locomotive from side to side, which however is less dangerous than the slewing of an engine without counterweights.

Marine engine builders often attempt to counterweight their engines in a similar way, but the transverse throw of the counterweight when the piston is at the middle of the stroke is likely to be quite as bad as the vertical accelerating force of the piston, when the engine is unbalanced, that is, if the engine is heavily counterweighted. Consequently marine engine designers are usually content to balance the crank shaft itself, or, at most, to counterweight for a part of the connecting-rod. To balance the crank shaft it is customary to extend the crank check or slab beyond the shaft and bolt on a cast-iron counterweight. The moment of the extension of the slab and the counterweight must be equal to the moment of the crank cheek and half the crank pin. Some engineers add the moment of one-third the weight of the connecting-rod; if more than one-third is provided for the transverse throw is liable to be unpleasant. There is an objection to counterweight on the part of the engine attendants, as it much enhances the danger of caring for the main bearings when the engine is running, especially to a man who has been accustomed to an unbalanced engine.

(*To be continued.*)

New York Fireboats in Action.

A serious fire in the down town district in New York on Thursday, February 9, called into use the powerful fireboats Robert A. Van Wyck and The New Yorker, in addition to twenty-five land engines and a water tower, besides a variety of other fire apparatus. It broke out early in the day in a block of buildings in the shipping district, close to South Ferry; the block being bounded by Front, Moore, South and Whitehall streets. Many of the buildings in the block were built of wood, very old and dried out, so that the fire burned with unusual fierceness. As the fire was too far distant from the water's edge to use the fixed nozzles on the fireboats the deck couplings were connected with hose to the water tower, which sent a regular cataract of water over the burning buildings, and also to the hand nozzles on shore. The weather was intensely cold, about zero, and the firemen suffered severely. As the water poured out of the windows and doors it froze, decorating the buildings picturesquely, as shown in our photograph. Notwithstanding the tremendous quantity of water used the fire was not put out until about $750,000 worth of property had been destroyed. In the photograph the two fireboats are shown with their noses against the bulkhead at the shore line. During the progress of the fire the tide fell and both vessels were aground. The suction openings, being so near the bottom, let into the pumps a good deal of dirt in suspension in the water, but this mixture was apparently as effective in smothering the flames as the unadulterated water of the East river. The reproductions of the photographs taken during the progress of the fire will be found on the opposite page.

According to report, work on the new yacht for Anthony J. Drexel, of Philadelphia, will be begun at once in the Scott yard at Greenock, on the Clyde. Designs have been prepared by G. L. Watson, and the yacht will be a large sea-going vessel of the Mayflower type. Her dimensions will be: Length, 268 ft.; beam, 36 ft.; depth, 20 ft., and net tonnage about 1,800 tons. She is to be fitted with twin-screw triple-expansion engines capable of developing about 4,700 I. H. P. and of drivng the boat at the rate of 17 knots.

The U. S. S. Buffalo arrived out at Manila February 3 with a cargo of supplies and 700 sailors as relief crews for Admiral Dewey's fleet. The voyage from New York occupied fifty-four days. This vessel, it will be remembered, was originally the Morgan liner El Cid, and later was purchased and fitted up as a dynamite cruiser by the Brazilian Government. Shortly before the Spanish war she was purchased by our Navy, and will now be used as a transport on the Pacific ocean.

A course in marine engineering has been established at Columbia University, New York, and the chair will be occupied by William Ledyard Cathcart, who has been acting in the same capacity at Webb's Academy.

CONSIDERATION OF THE VOLTAGE USED IN ELECTRIC SHIP LIGHTING.

BY ALTON D. ADAMS.

The voltage or electric pressure to employ is one of the first and most important points for decision in the design of an electric plant for ship lighting.

In the United States Navy the standard is 80 volts; isolated plants on land usually employ 110 volts, but in some more recent work a 220-volt pressure has been selected. Just why the 80-volt pressure has been so much used on ships seems uncertain, but a desire to keep near the pressure required for searchlights is sometimes given as the reason.

Search lamps require about 45 to 50 volts at the arc and a drop of 15 to 20 volts, through resistance in series with the lamp, to insure steady burning, so that about 65 volts is all that is necessary for these lamps.

For isolated land plants the pressure of 110 volts was selected at a time when satisfactory incandescent lamps could not be had for much higher pressure, and the advantages of uniformity have operated against moderate changes in lamp voltage.

Within the last few years improvements have made it practical to produce the 220-volt lamp, and it is being slowly introduced on new work. In the future an increasing number of new plants, having lamps at some hundreds and thousands of feet from the dynamo, will beyond doubt use the 220-volt lamp; but for the present a 110-volt lamp must be regarded as standard for most isolated plants.

Questions of insulation and fire risk mainly tend to retard change to the 220-volt system, because during its years of use there have been perfected for the 110-volt system a line of fixtures and fittings known to be safe and reliable to a high degree. It is also known that many of the 110-volt fittings will not stand the strain of 220 volts with safety, and time and experience will be required to perfect fittings for the higher pressure. A parallel can be drawn with steam, for it is well known that steam pipes and fittings which are quite satisfactory at 110 lb. pressure would not be safe at 250 lb.

The advantage obtained by increased voltage of incandescent lamps is due to the law that for any given distance the weight of copper required to supply any number of lamps varies inversely as the square of the voltage. For example, the relative weights of copper wire to feed a certain number of incandescent lamps at any distance from the dynamo on the 80, 110 and 220 volt pressure will be as $(80)^2 = 6,400$, $(110)^2 = 12,100$ and $(220)^2 = 48,400$. This shows that wiring at 80 volts requires about twice the copper necessary for 110 volts, and wiring at 110 volts about four times the copper for 220 volts.

Another fundamental law of electric circuits is that the weight of copper wire to feed any number of lamps of given voltage varies directly as the square of the distance between the dynamo and lamps. Thus 100 lamps 75 ft. from the dynamo require but one-quarter the copper necessary if they are 150 ft. from the dynamo.

The full theoretical advantage due to increased voltage cannot be obtained in the small branch wires of a system, as these wires must not be reduced below a certain size for reasons of mechanical strength. This consideration, however, effects the saving possible with increased voltage but little, as most of the weight is in the large feed wires and mains.

From the two fundamental laws already stated it is evident that the greater the distances between dynamo and lamps the more saving is to be effected by the use of high voltage.

Coming now to the practical question of what voltage to employ for the average ship plant, the 110-volt pressure offers a saving of nearly one-half the copper required by the 80-volt wiring, while the same class of fixtures and fittings are used for either pressure. The 220-volt wiring requires only one-fourth the copper of the 110-volt; but a more expensive and to some extent untried class of fittings must be used and greater care taken to insure insulation throughout.

As most ship plants do not operate lamps more than two or three hundred feet from the dynamo, so that total cost of wire is but a moderate part of that for the entire plant, as risk from fires due to poor insulation are especially dangerous at sea, and as repairs to fittings may be especially inconvenient during a voyage, the pressure of 110 volts seems best suited for ship plants at the present time. The fact that search lamps require, with the resistances necessary for steady operation, only about 65 volts seems the only valid objection to the 110-volt pressure, and this in a plant of medium or large capacity is of small moment. Moreover, the 80-volt pressure is open to the objection of waste, though not in the same degree.

Consider the case of a nominal 4,000-candle-power searchlight requiring 20 amperes at about 50 volts. To reduce a pressure of 80 volts on mains to 50 volts at the lamp a resistance coil must be connected in series with the lamp to have in it a drop of 30 volts with 20 amperes flowing. This resistance, therefore, consumes power at the rate of $20 \times 30 = 600$ watts, or $600 \div 746 = .8$ horse power. With a 110-volt pressure on the line the resistance with lamp must cause a drop of $110 - 50 = 60$ volts, and the power consumed with 20 amperes is $60 \times 20 = 1,200$ watts, or $1,200 \div 746 = 1.6$ H. P. The difference in regulating resistance loss between the 80 and 110 volt system is therefore $1,200 - 600 = 600$ watts or .8 horse power, which in case of a 50-horse-power plant would be less than 2 per cent. The fact that a searchlight is usually in operation a small part of each day makes the relative loss still smaller on the average. On the other hand the amount of copper required for a given per

SCENES AT THE WATER-FRONT FIRE NEAR SOUTH FERRY IN NEW YORK CITY.

cent of loss in the 80-volt wiring will often lead to a larger per cent of loss than would be employed with 110 volts, so as to more than offset any saving in searchlight resistance.

The enclosed arc, which has about the carbon points a small glass or porcelain cylinder, nearly air tight, requires about 80 volts at the lamp and would thus save one-half the resistance-coil loss of a lamp on the 110-volt circuit. This 80-volt arc lamp could not be used on the 80-volt circuit, as arc lamps operated from constant pressure mains require the line pressure to be reduced at least 25 per cent to insure steady working of the lamps. Not only does the 80-volt system require twice the weight of copper wire, but the capacity of main switches, number of brushes at commutator and the size of contact surface on commutator must be about one-half greater than that for the 110-volt plant.

The commutator requirements just named add something to the length and weight of dynamo and to the attention necessary at brushes. Having so little against it and so many points of advantage the pressure of 110 volts may reasonably be expected to grow in favor for ship-lighting plants.

Lord Charles Beresford, the dashing Britsh naval officer, is now in this country on his way home from an official visit to China in the interest of the British Associated Chambers of Commerce. He is one of the strongest advocates of the "open-door" policy in the Far East, and while here he is endeavoring to obtain the views of American Chambers of Commerce with regard to the future development of trade and commerce with the Chinese Empire. In the course of an interview which he gave to a representative of the press he said:

"The very astounding performance of the battleship Oregon in her long run from San Francisco to the scene of hostilities in the Atlantic challenged the admiration of naval men throughout the world. While this is a remarkable tribute to the genius of the builders and those who equipped her, it could not have been accomplished without the most devoted attention to details on the part of the captain, officers and ship's company, particularly the chief engineer, engineers and firemen, who stood the long strain so manfully."

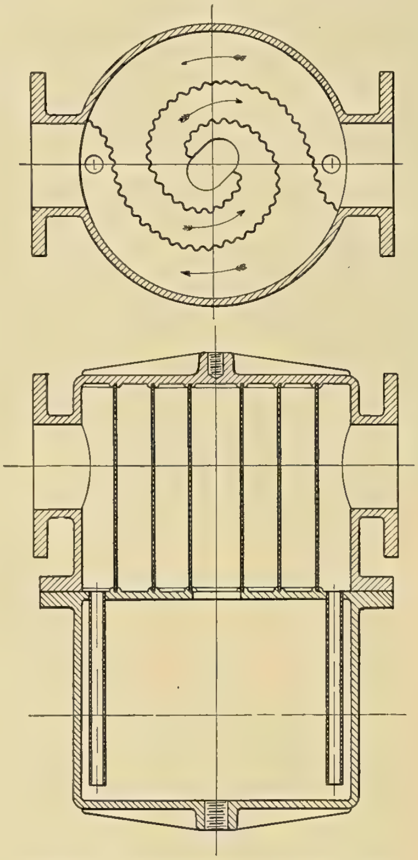
Lord Beresford is a high authority in naval matters, not only theoretical, but practical. He took part in the bombardment of Alexandria in command of H. M. S. Condor, and for special bravery in placing his vessel close in he was rewarded by the famous signal made by the British Admiral, "Well done, Condor."

The new steel yacht Willada, for Colonel William Hester, of Brooklyn, now under construction at Wilmington, Del., will measure: Length, 102 ft.; beam, 16 ft. 6 in.; depth, 9 ft. 3 in. She will be fitted with a triple-expansion engine, 9 in., 14 1-4 in. and 23 1-2 in. by 14 in., built by the Fore River Engine Co., of Weymouth, Mass., and will have an Almy water-tube boiler. Colonel Hester is well known in yachting circles as owner of the sloop Wizard.

IMPROVED APPARATUS.

Hutchison Separator.

The accompanying figure shows a new steam and oil separator, designed by Richard Hutchison, Tremont Building, Boston. The body is cylindrical and divided into upper and lower compartments by a horizontal partition. In the upper compartment a corrugated copper diaphragm is arranged so that any vaporous current passing through this chamber is made to travel by an inverging and outverging spiral path always in the same horizontal plane. The steam or vapor is not only brought in contact with a large amount of impact surface, but foreign matter, being heavier than the current, is thrown by centrifugal action against the diaphragm as well, from whence it runs down the corrugations, without again crossing



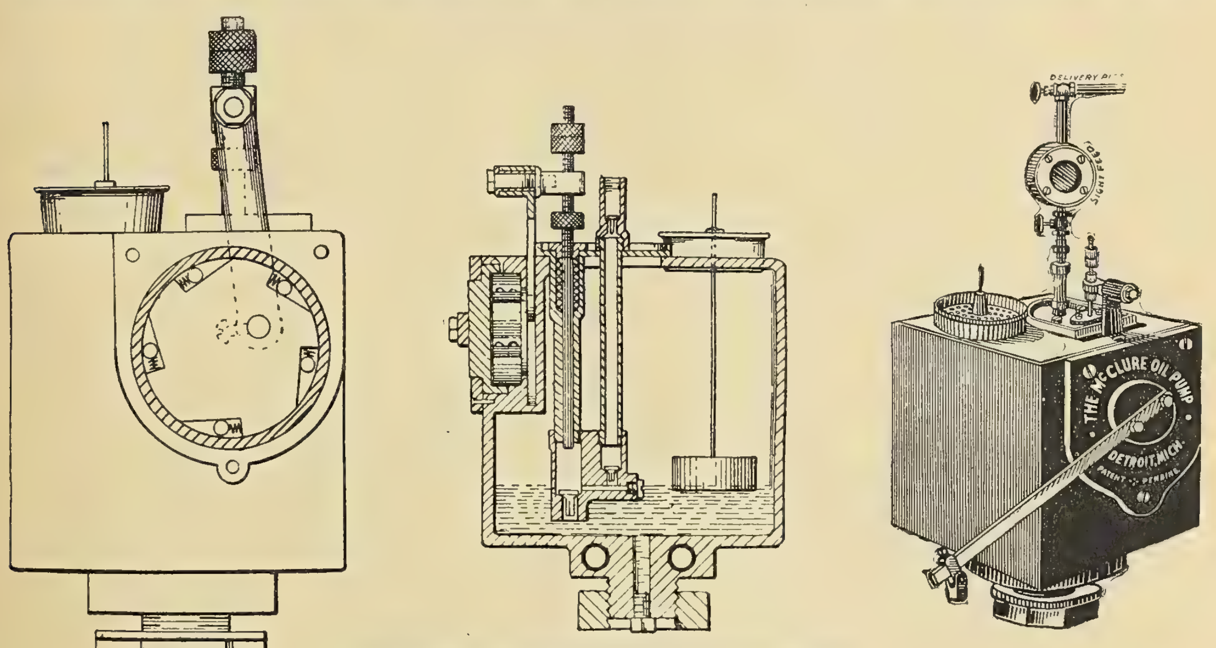
SECTIONS OF HUTCHISON SEPARATOR.

the current of vapor, into the reservoir below. This reservoir can be drained automatically by a trap. The copper diaphragms in the cut shown here are held in place by their serrated edges being forced into taper spiral grooves, when the upper and lower parts of the separator are bolted together. The elliptical opening through the centre of the horizontal partition will usually be of ample capacity, but small drips are provided as well in the event of an unusual influx of water, when some might be carried past the central opening. Either nozzle may be used as the inlet, so that as regards the water glass rights and lefts are not necessary.

These drips are carried down so that the water in the lower chamber will form a seal and prevent steam short-cutting down one and up the other. The lower chamber is designed unusually large, with a view to having it act as a receiver for the engine containing steam supply ample to satisfy an unexpected demand, thereby preventing pulsations and combining the consequent advantages. These separators below, 4 in. in size, are cast complete in two pieces and bolted together by a vertical body flange; from 4 in. to 8 in. they are made as shown in the cut, and above 8 in. the shell is steel plate, with cast steel nozzles riveted on.

Lubricating Oil Pump.

The illustrations show an improved form of forced feed, known as the McClure lubricating oil pump. It is intended for cylinder lubrication either with the main engines, or dynamo, fan or steering engines, and can also be used for lubricating working parts, such as the crossheads and guides. The pump is attached to the frame of the engine and is connected with some moving part, so that the speed of the pump will vary with the speed of the engine. The pump body is made of cast iron, with a capacity of one quart or half a gallon, according to size. This contains the pump mechanism, as shown in the sectional view. The pump plunger is fitted with adjustable nuts, so that the quantity of oil delivered at each stroke can be regulated very exactly. The plunger is driven by a link attached at its lower extremity to a ratchet plate, which is rotated by contact with a ring or cap and arrangement of rollers, this ring being connected outside with a reciprocating portion of the machine to be lubricated. The valves are inserted from the top of the lubricator, so that they can be withdrawn readily for examination. A cork float with indicator-rod is used to show the oil level in the receiver. When used for cylinder lubrication an independent sight feed attachment is supplied. The makers state that this lubricator has been used with excellent results. The address is the McClure Oil Pump Co., Detroit, Mich.



INTERIOR AND EXTERIOR OF McCLURE OIL PUMP.

Generating Set for Shipboard.

A compact generating set for ship lighting is shown in the accompanying engravings of a B. F. Sturtevant installation on the steamship Berlin, of the American Line. The engine is of the twin-cylinder, high-pressure, fly-wheel-governed type, with cylinders 9 in. dia. and 5 1-2 in. stroke, direct connected to a continuous-current generator, having a capacity of 40 K. W. Both engine and generator are mounted on one base, and the weight, set up ready for use, is 10,000 lb. The engine is designed with a view to the specially trying conditions of shipboard work, having all parts made with good proportions of the highest class materials, and with large wearing surfaces. The two cylinders and valve chests are in one casting, carried on stout columns, square at the back and turned in front. Each cylinder has a separate piston valve, and both are worked from the same crosshead, which receives its motion from a rocker arm fulcrumed between two of the supporting columns and operated by the eccentric rod, connection with the rod being made by a ball and socket joint. The position of the eccentric is controlled by the fly-wheel governor, which is of the Rites type. The engine cranks are set opposite, that is, at 180 deg., so that as one piston goes up the other goes down. Both valves, however, travel in the same direction at the same time. In order that, notwithstanding this, steam may be admitted to the top of one cylinder at the same time that it is admitted to the bottom of the other, the inside of one valve is used for steam and the outside for exhaust, while in the other valve the steam is on the outside and the exhaust on the inside. Live steam entering, as shown in Fig. 1, passes to the ends of valve 1, as shown in the section through *A B*, Fig. 2, and to the middle of valve 2, as shown in the section through *C D*, Fig. 3. When the valves are in the positions shown, cylinder 1 will be taking steam on top and cylinder 2 on the bottom. The valves are fitted with snap rings and travel in removable bushings. The crossheads are of the slipper type, with projecting crosshead pins, the rod ends being yoked, thus furnishing ample pin surface. The crank pins are 4 1-2 in. long and 4 in. dia. The crank shaft is

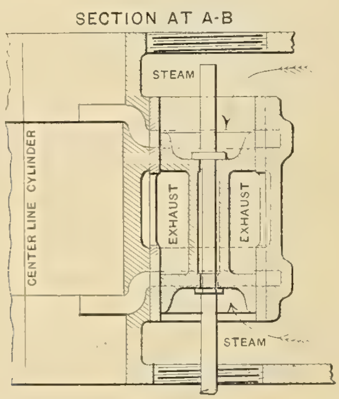


FIG. 2.

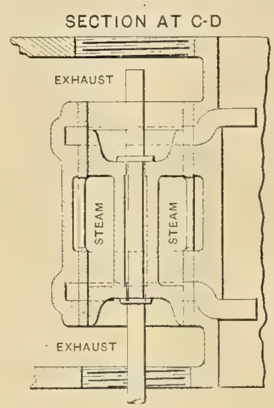
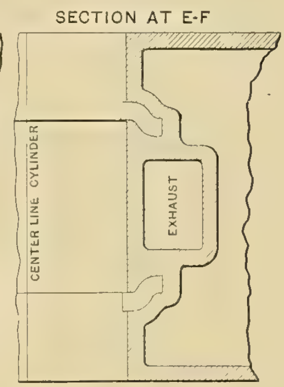


FIG. 3.



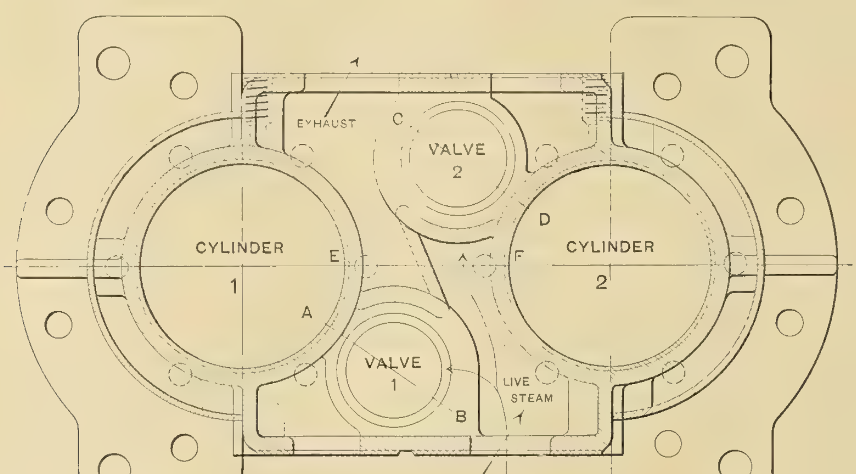


FIG. 1.

SECTIONS THROUGH CYLINDERS OF STURTEVANT ENGINE.

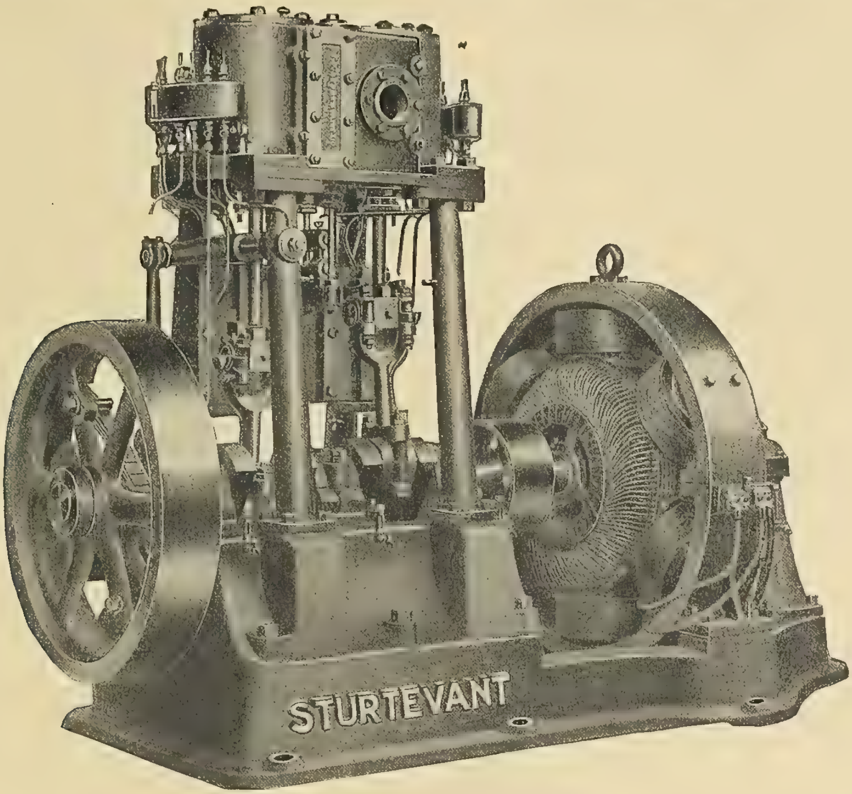
4 in. dia. Forged steel is used for both the connecting-rods and crossheads, and the shaft is also forged in one piece. An oil tank upon each end of the cylinder casting is provided with individual sight feed oilers and connections to the various bearings. The engine is rated at 60 H. P. at 625 revolutions. On an extension of the engine shaft, with coupling between, the armature of the dynamo is carried, and the outer bearing is of the special ring-oiler pattern.

The field ring of the generator is of cast steel with wrought-iron pole pieces and cast-iron shoes. The armature is of the barrel-wound type, built up on spiders and with cast-iron flanges bolted thereto, forming supports as well as cylindrical receptacles for the projecting ends o1 the coils, and also protecting them from any oil that may be thrown. The interior surface of the armature is perfectly smooth, offering no opportunity for the collection of oil or dust. Ventilation is effected by the use of specially constructed veins, forming air ducts between the laminae of the coil, thus converting the armature into a blower, and creating a strong draft through the windings. The brushes are of the reaction type, and when properly set insure sparkless operation under all changes from no load to 25 per cent overload. The temperature rise after ten hours' full load run is limited to 90 deg. For the illustrations here printed we are indebted to our contemporary *Power*. Additional particulars can be had from the manufacturers, the B. F. Sturtevant Co., Jamaica Plain, Mass.

Portable Air Compressor.

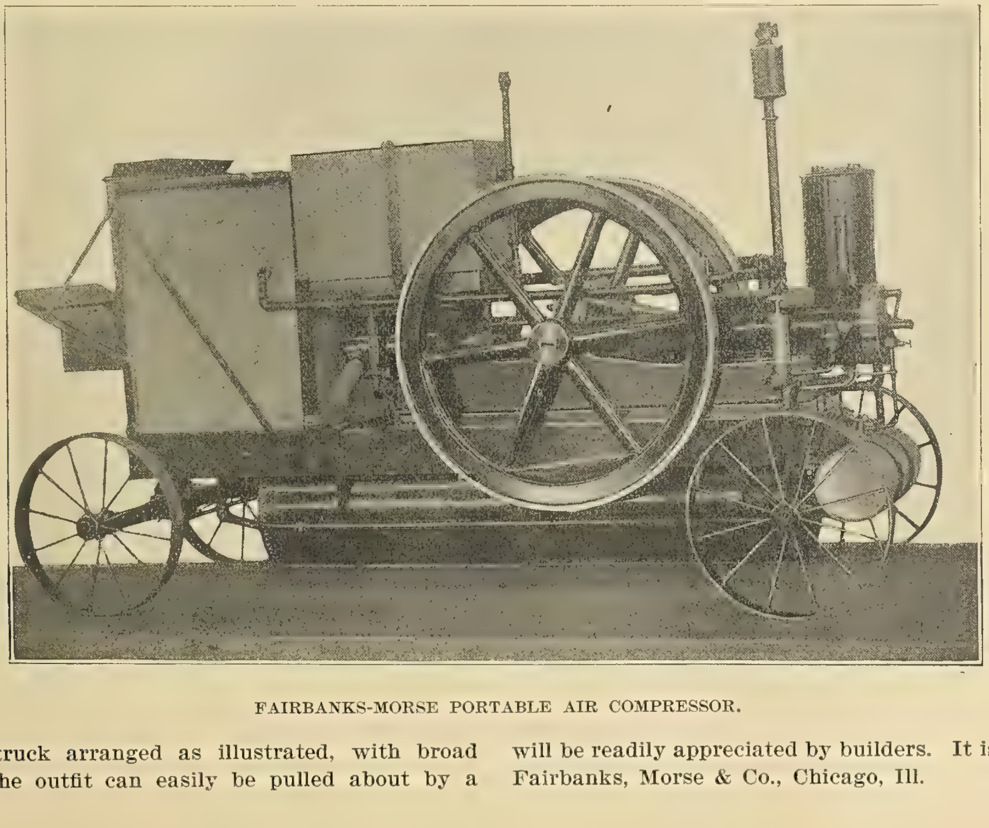
Our illustration shows a 12 horse power Fairbanks-Morse gasoline air compressor, which is mounted on an iron frame truck, the object being to make it a portable outfit which could be conveniently moved about for field work. The outfit is mounted complete with all accessories; two tanks are provided for cooling water, one for each cylinder. The air receiver is suspended under the frame and a tank for gasoline is suspended at the back of the truck.

This compressor, like the standard stationary combination, is fitted with a mechanical unloading device by which a constant pressure is maintained in the air receiver tank. An electric igniter is used for



STURTEVANT GENERATING SET.

firing the charge in the cylinder, and a self-starting device is provided for setting the engine in motion.



FAIRBANKS-MORSE PORTABLE AIR COMPRESSOR.

With a truck arranged as illustrated, with broad wheels, the outfit can easily be pulled about by a team of horses. One of these outfits was furnished to the Cleveland Shipbuilding Co., Lorain, O. In a large yard or for repair work, which has often to be done remote from the shops, the value of this outfit will be readily appreciated by builders. It is made by Fairbanks, Morse & Co., Chicago, Ill.

MARINE ENGINEERING

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AN effect of the Spanish war has been to forcibly direct the attention of foreign nations to the influence of America as a sea power, not merely naval, but mercantile. This has been made manifest by the frequent articles and observations lately printed in foreign papers bearing on the subject. Prior to the war the interest of foreigners in this expression of our national energy was languid. They knew that ships could be and were built here, but those in the foreign trade were not numerous; the American flag was a stranger to many ports and infrequently seen in any. The marine activities of other nations were ever present, and very naturally the objects in view received more attention than those remote. Manila and Santiago had a seismic effect, however, and now the leading maritime nations are standing around wondering what will happen next. From professional engineering circles abroad, especially British, comes the admission, given condescendingly, that very probably the American people will be able to build up a merchant marine and get their share of the carrying trade. Well, the American people can do it, and will do it, and when they have finished a good many ship owners and, probably, shipbuilders abroad will have gone out of business. The foreign capitalist, who looks at the subject with no professional bias, appreciates the situation more fully than the engineer. His opinions are voiced in an important article published recently in the *Statist* of London, and reproduced in this issue on another page. This notes the great national desire for an adequate merchant marine, and the present conditions in the steel trade, which permit the production of high-grade material as cheap or cheaper than it can be made abroad. There are indications even now of a great awakening in shipping circles here. Shipyards on the coast are filled with orders, and new plants which but recently were either inactive or not in existence are now engaged in turning out steam tonnage. A rough estimate of the amount of work of all kinds in the shipyards of the country places it at nearly half a million tons, of a money value away up in the millions. These, however, are simply evidences of the spirit which prevails and which will finally place this country in its proper position as a maritime nation. There is much to be done yet in the way of legislation, in interesting capital in shipping, and in the proper equipment of yards, so that work can be done economically, enabling the builder to make competitive prices and a profit at the same time. Business conditions are favorable to an early expansion of the merchant marine; new possessions have been acquired, and, of probably greater mercantile importance, manufacturers of all sorts of wares are successfully reaching after foreign trade as never before. When such trade reaches sufficient proportions indirect shipments, which are now made to many ports, will no longer be profitable, and direct lines will result. There is a tremendous amount of work to be done, however, before these much-desired results are obtained and America heads the list in merchant marine tonnage. Every one who is interested can help the movement along by personal exertion, no matter in how limited a sense. There is now no greater humiliation possible to an American than to visit any of our principal seaports and note the invariable absence of the American flag and the presence of foreign flags on steam tonnage in the foreign trade. Thousands of tons of shipping are added yearly to lines trading between American and foreign ports, and the proportion owned and operated by Americans is practically nothing. Even in the vitally important and profitable transatlantic trade the amount of real American tonnage is pitifully small.

ONE of those fortunate accidents which recall the saying that everything that happens is for the best occurred at the Navy Yard in New

York on the night of February 15, and resulted in the destruction of the machine shop by fire. After the members of the engineering staff and all the workmen had gone home fire broke out, from causes unknown, in the upper portion of the building, and though details of sailors and the city fire department did very effective work the building was ruined. But for this speedy and unexpected removal the shop would be now, and for how long in the future no one knows, a monumental disgrace to the most important Naval station in the country. A more unsuitable or inconvenient building for such a purpose it would be hard to design: if we mistake not it was originally intended for a textile factory. It was L-shaped and storied, dark and depressing, and altogether out of date. Then too there was a wonderful collection of antiquated tools within its walls. It is, of course, a matter of congratulation that the fire did not occur during the late war, when a tremendous amount of work was turned out there, and that in a hurry too. Now, however, there is opportunity to take time to replace the old shop with a thoroughly modern structure, in which questions of hygiene, shop management, which includes a proper disposition of machines, and adequate accommodation for the executive staff will be well considered and worked out. A thoroughly modern equipment of modern machine tools and apparatus for economically handling work goes without saying. It should be a matter of pride with those concerned to have a shop that would be adequate for the future needs of the Navy, and that would serve as a model for private shops to copy with advantage. The Navy has done so much for the country in raising the standard of quality of material that it could, now that the opportunity is at hand, create a new standard in machine-shop design and equipment.

IN the course of a debate in the House recently Mr. Bromwell, of Ohio, proposed that one of the new war vessels be named "The American Boy," and a number of very unsentimental gentlemen opposed him. It would be of passing interest to know how many of these members had familiar experience with the American boy in their homes. As to the proposition, however, it was one for which the Navy Department will be devoutly thankful, seeing that the list of States is limited, and naval heroes' names are being rapidly exhausted in giving identity to our torpedo boats and destroyers. The name of a ship is a matter of great consequence, and we therefore timidly venture a few suggestions. In some way the ship should be typical—a great opportunity for the designer to show his sense of the fitness of things. (Here we are in doubt whether "The American Boy" should be referred to as "he" or "she." Usage decides in favor of "she.") Well (his?), her figurehead should display a red Indian in full war paint, and she should be supplied with a syren of special pattern that would let out a regular Comanche war whoop in time of trouble. Then she should be chock full of guns, all rapid-fire, and should carry an extra supply of ammunition so as to be able to fire often and fire fast. There would be no doubt of her popularity among Young America; did she but touch at any of our ports the public schools would be closed, for no American boy could be expected to pay attention to the three Rs when his namesake was in port. There would be this drawback about the name, that when the vessel came of age her (his?) name would have to be changed to "The American Man," and then the change of name would call for an appropriate change of appearance, such as a lengthening or broadening out, or the substitution for the matured vessel of a larger and more powerful ship. Though the name would be very good for a starter we believe that it is too general to be altogether satisfying. Would not it be better to build a "Boy" class, just as the British have an "Admiral" class, for example? Then distinctive types of "Boy" could be properly represented; or, better still, use the "Boy" to distinguish the type of vessel so named. For instance, "The Butcher Boy" would be an appropriate name for one of those fat, dumpy monitors that would have a slow, steady gait. Then "The Newsboy" would call to mind a diminutive, smart little gunboat, quick in its movements, that could scrap on the least provocation and stand any amount of hard knocks. Then for a really slow, vacillating sort of vessel, say of the collier type, what name could be more suitable than "The District Messenger Boy?" She would live up to her reputation of getting to any point when she was good and ready. "The Good Boy" should be fitted with twin rudders, and be warranted to get in and out of New York harbor without grounding; and "The Bad Boy"—well, no hostile commander could risk an engagement when he was around. "The Tomboy" would be a saucy little cruiser that could always ship a crew. Space does not allow further examples, though they are numerous, but the foregoing we respectfully submit to the Committee on Naval Affairs.

BRITISH VIEW OF THE FUTURE OF AMERICAN SHIPBUILDING AND SHIPPING.

Perhaps the most important economic question of our time is connected with the development of the iron and steel industries of the United States and the probable consequences of that development, not only on the cognate industries of Europe, but also on the whole maritime relations of the commercial world, says the *Statist*, London's financial authority. In the palmy days of the proud wooden "clippers," the Americans had the bulk of the transatlantic carrying trade and the best of the carrying trade between Great Britain and China and Australia. Their wooden vessels were not only things of beauty, but were, with national ingenuity, constructed so as to combine high speed with the largest possible cargo capacity, and with every possible contrivance for saving labor. We are, indeed, apt to forget that America once divided with us the world's carrying trade, if, indeed, for a time she did not have the lion's share. It is only since the age of iron that she has lost that position; though she need not have lost it had not the fiscal policy that has developed since the civil war prevented her both from importing material wherewith to build ships at a profit, and also from buying ships from foreigners, except under practically prohibitive conditions. And now we are face to face with two momentous facts that presage a revolution in the world's shipping and a formidable competitor with Great Britain as the world's common carrier. These facts are (1) that the people of the United States have now become impatient of their stifling navigation laws, and are craving for a national merchant navy; and (2) that now, for the first time in their history (since the decline of the wooden ships), are the Americans able to produce shipping material on a level with Great Britain.

It is probable that Congress will soon revise, if not repeal, the navigation laws. Leaving, however, the fiscal aspects of the question for the present, we propose to take a rapid view of America as an actual iron and steel producer and as a prospective builder of high-class modern iron and steel vessels.

In the first place, we have to note that the States have not yet reached their maximum power in the production of pig iron. Their furnaces are much larger than ours, and their proportion of obsolete types must be small, indeed, compared with the number of antique examples we have still standing in England, Scotland and Wales. At any rate, their existing furnaces are computed to have a capacity of over a million tons per month. The actual production has not yet reached that capacity, and there is, of course, no limit but that of capital to the number of new furnaces which may yet be built. Can such enormous quantities be produced as cheaply as in Britain? The truth seems to be that in the more favorably situated works of the United States, and with the more economically worked furnaces (which are three or four times the size of ours), the prime cost of American pigs is below that of either Scotland, Cleveland or Cumberland in the respective qualities. This is a point on which we must speak with some diffidence, as it is a matter for industrial experts, and we by no means accept the shipments of American pigs to England as evidence of profitable business. But experienced iron manufacturers with whom we have conversed have expressed their belief that the southern States of America, and those of the northern States that are within easy reach of the lake ore, can certainly smelt pigs more cheaply than we can. It is enough if they can do it as cheaply, when we pass to the next stage of competition.

And in all stages the Americans have the advantage of cheaper fuel. Barring India, American coal is now the cheapest in the world, and on the average is to the industrial consumer fully 6 cents per ton cheaper than the average in England, Scotland and Wales. This is an advantage, of course, that tells at every stage of manufacture. It is also a noteworthy fact that wages in the American iron industry have been materially reduced of late years, while the producing capacity has also increased. The eight-hour movement is unknown in the States and the continuity of energy is one of the great factors in American industrial development. To take one example: At the Pennsylvania blast furnaces, in 1880, the wage cost was about $2.50 per ton of pig iron. By 1890 the wage cost was reduced to $1.25, and now it has been pretty generally reduced to about 50 cents per ton. Again, the average annual output per employee was, in 1880, 190 tons. It is now about 550 tons. These facts speak for themselves, and those who run can read their significance.

Now, take another fact in relation to the American iron industry. Until within recent years that industry practically depended on the development of the railway systems of the States. When railway building was slack the iron industry was depressed, and vice versa. But of late years, while railway building has shrunk to insignificant proportions, the production of all kinds of iron and steel has enormously increased. Look at the following figures:

Year.	Mileage of New Railroad Built. Tons.	Output of Pig Iron. Tons.	Output of Finished Iron and Steel. Tons.
1882	11,500	4,623,323	3,500,000
1887	13,000	6,417,148	5.250,000
1897	1,880	9,652,680	7.000,000

Of course, this means that producers of American iron and steel have found new and larger outlets for their material in other industries than railway building.

One outlet may now be accounted the making of steel rails for export. For American steel rails are now being supplied on contract to British India, Russian Asia (the Trans-Siberian line), the West Indies, Nova Scotia and Canada generally, South Africa, Hawaii, and even Ireland. In one month last year the two largest steel rail companies are said to have booked between them no less than half a million tons, the larger proportion of which was for export. Nor is this surprising, for prices in America (under the stress of constantly expanding competition) have been coming down as they have been going up in Europe. Thus, in 1896, the price of steel rails was $25 per ton in the United States, $27.50 in Germany, and $24.34 in Great Britain. In 1898 the current prices were $19.50 in the United States, $29.34 in Germany, and $23.12 in Great Britain. The reduction in America is not due to competition alone, but largely to the reduced cost of material and greater economy in production.

It is, of course, the reduced cost of production that has given America a chance in foreign markets that she never had before. The surplus of many American manufacturers has been often enough "dumped" into foreign countries—especially Canada—in order to relieve the home markets. But the business now being done by Americans in iron and steel cannot be regarded as of the "dumping" character. They are cultivating an export trade, and with such success that in the year ending June 30 last the exports of raw and manufactured iron and steel amounted to $70,367,527, as against $57,497,872 in the previous year. These exports consisted of 235,868 tons of pig iron, 232,552 tons of railway iron, 64,745 tons of iron wire, 60,195 tons of scrap iron, 30,585 tons of structural iron and 16,100 tons of steel billets and ingots. The total quantity of all sorts sent to Great Britain was 150,000 tons, and nearly all the rest was sent to countries accustomed hitherto to buy from us. In the nine months ending September 30 the exports of steel rails amounted to 222,973 tons, valued at $4,465,087. These figures compare with 88,573 tons and $1,891,724 in the corresponding portion of 1897, and with 50,841 tons and $1,189,106 in the corresponding part of 1896.

The largest buyers of the increased quantity have been Canada and Japan; and it is well to remember that it was stated in Parliament last session that the lowest tenders for rails for the supply of the Indian railways were American. As to Japan, which used to get all her rails from us, we note the following in a special report by Mr. Lyon, United States Consul at Hiogo:

"In 1896 the United States exported to Japan only a little more than one-sixth as much railway iron as England did; but in 1897 a very notable increase took place from the United States in such shipments, and exportations from the two countries stood thus: Great Britain, $810,091; United States, $625,083. At this rate another year will show the United States to have left its competitor in this export far behind."

That may or may not be; but the enormous advantage possessed by the United States in the coming market for railway iron in China is an important factor in the development of production now taking place. That development has gone on to steel ship plates, which are now being shipped to this country for shipbuilding.

The point we have sought to bring out is that America has now so developed her iron and steel industries that she must find fresh outlets for her products. Such outlets she is finding, as we believe with profit, in foreign markets for certain products. For other products, however, she will need to create a new shipbuilding industry of her own; and what has been done or is being done in that connection we must reserve for future examination. No thoughtful man, acquainted with the American character, who considers the situation, can fail to perceive that the greatest competition to be faced by British industry and enterprise in the future is that of American shipbuilding. It may be deferred a few years, but it is bound to come.

Wages on British and American Steamships.

To give our readers an idea of the rate of wages paid on oil tank steamers under the British and American flags, says the *American Shipbuilder*, we obtained the following facts: The Alleghany, as will be remembered, was wrecked in these waters and afterward became the property of Lewis Luckenbach, 129 Broad street, New York. She was extensively overhauled by Neafie & Levy, and is now in the transatlantic oil trade, having left this port January 18, bound for Dover, England, for orders. She will return in ballast. The wages paid the crew are as follows, under the two flags:

American.		British.	
Captain,	$125	Captain,	$100.00
1st Officer,	75	1st Officer,	47.50
2d Officer,	60	2d Officer,	35.00
Chief Eng.,	125	Chief Eng.,	90.00
1st Asst.,	70	2d Eng.,	60.00
2d Asst.,	60	3d Eng.,	35.00
2 Oilers,	40 each.	2 "Greasers,"	25.00 each.
Steward,	40	Steward,	30.00
Cook,	35	Cook,	26.50
8 Sailors,	25 each.	6 Sailors,	20.00 each.
6 Firemen,	35 each.	8 Firemen,	21.50 each.
2 Coal passers,	30 each.		

The above table shows that the Alleghany cost $764 per month under the British flag and $1,140 per month under the American flag, for wages alone, making a total of $4,512 per year in favor of the British ship. The Alleghany carries 26 men, under the American flag, which is two more than she carried under the British flag. This ship burns 22 tons of coal per day, making a speed of 11 knots. The food is much better (and consequently costs more) on American steamships than on British, although there is little, if any, difference in the food given to sailors on sailing ships under the British or American flags. The dimensions of the Alleghany are: Length, 320 ft.; beam, depth, 19.2 ft.; British tonnage, net, 1,911; gross, 2,914. Tonnage under the American flag, 1,889 net, 3,009 gross; engines, triple-expansion, 25, 40 and 66 in. by 45 in. stroke. The vessel was built by Craig, Taylor & Co., in 1890, at Stockton, England.

EDUCATIONAL DEPARTMENT.

CALCULATIONS FOR ENGINEERS—AN AID TO CANDIDATES FOR MARINE PAPERS—VI.

BY DR. WILLIAM FREDERICK DURAND.

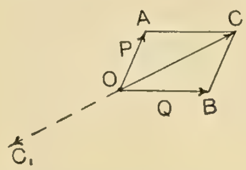
[12] Propositions in Statics.

Following are a few simple propositions in statics given without proof.

(1) A force may be transferred along its line of action without changing its effect.

(2) Two forces equal and directly opposite will balance or produce equilibrium.

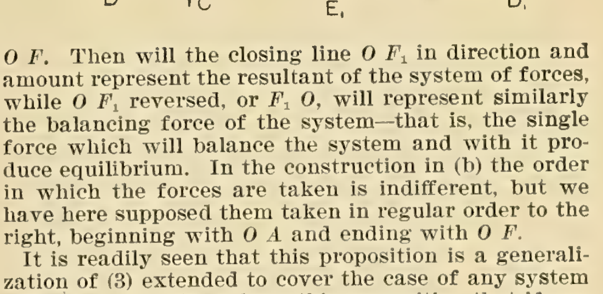
(3) PARALLELOGRAM OF FORCES. If two forces whose lines of action meet in a point O are represented in amount and direction by the lines $O\ A$ and $O\ B$, then



will the resultant of these two forces be represented also in amount and direction by the diagonal $O\ C$ of the parallelogram $O\ A\ C\ B$ erected on $O\ A$ and $O\ B$ as adjacent sides.

(4) A force $O\ C$, represented by the diagonal $O\ C$ reversed will balance $O\ C$ or R, and therefore will balance P and Q.

(5) POLYGON OF FORCES. Let there be a system of forces represented as in (a). In (b) starting at any point O draw $O\ A_1$ equal and parallel to $O\ A$. Then from A_1 as starting point draw $A_1\ B_1$ equal and parallel to $O\ B$, and so on, drawing finally $E_1\ F_1$ equal and parallel to

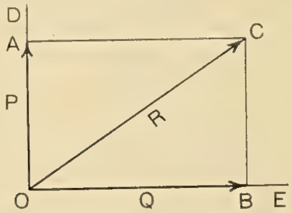


$O\ F$. Then will the closing line $O\ F_1$ in direction and amount represent the resultant of the system of forces, while $O\ F_1$ reversed, or $F_1\ O$, will represent similarly the balancing force of the system—that is, the single force which will balance the system and with it produce equilibrium. In the construction in (b) the order in which the forces are taken is indifferent, but we have here supposed them taken in regular order to the right, beginning with $O\ A$ and ending with $O\ F$.

It is readily seen that this proposition is a generalization of (3) extended to cover the case of any system of forces. It follows from this proposition that if any system of forces may be represented as in (b) by the sides of a completely closed polygon, then such system will produce equilibrium, for the resultant in such case would be o. Again in such case any force may be considered as the *balancing force* for the system composed of all the others, and any force reversed may be considered as the *resultant* of the system composed of all the others.

(6) COMPONENTS. In the figure the two forces P and Q are at right angles. In such case they are known as the *components*, or, more correctly, the *rectangular*

components, of their resultant R along the lines $O\ D$ and $O\ E$. In general the component $O\ B$ of any force



$O\ C$ along any line $O\ E$ is found by drawing from C a line $C\ B$ perpendicular to $O\ E$, thus determining the length $O\ B$.

(7) Conditions for Equilibrium. The conditions for the equilibrium of any body are as follows:

(a) The sum of all the components of all the forces acting on the body taken along any line, or more particularly along any pair of lines at right angles, must balance.

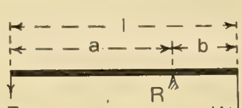
(b) Taking any point as origin, the sum of the moments of all the forces tending to turn the body in one direction about this origin must equal or balance the corresponding sum in the other direction.

If all the forces act at a single point, only the first of these conditions is necessary. If instead they act at different points of a body, both conditions are necessary.

[13] Mechanical Powers.

Lever. A lever consists essentially of a bar which supports a weight or applies a force at one point by means of a force applied at another point, the bar in the meantime being supported and turning about a third point called the fulcrum. According to the relation of these three points, levers are divided into three classes as below.

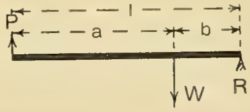
Lever of the First Class. In this the fulcrum R is between the points of application of the forces P and



W. The following proportions and equations apply to this case:

$$P : W :: b : a \quad \text{or} \quad P\,a = W\,b$$
$$P : P+W :: b : l \quad \text{or} \quad P\,l = (P+W)\,b$$
$$W : P+W :: a : l \quad \text{or} \quad W\,l = (P+W)\,a$$
$$P = \frac{b}{a}\,W = \frac{b}{e}\,(P+W) \qquad a = \frac{W}{P}\,b = \frac{W}{P+W}\,l$$
$$W = \frac{a}{b}\,P = \frac{a}{l}\,(P+W) \qquad b = \frac{P}{W}\,a = \frac{P}{P+W}\,l$$

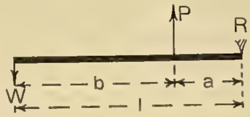
Lever of the Second Class. In this the weight lifted or resultant force W is between the applied



force P and the fulcrum R. The following proportions and equations apply in this case:

$$P : W :: b : l \quad \text{or} \quad P\,l = W\,b$$
$$P : (W-P) :: b : a \quad \text{or} \quad P\,a = (W-P)\,b$$
$$W : (W-P) :: l : a \quad \text{or} \quad W\,a = (W-P)\,l$$
$$P = \frac{b}{l}\,W = \frac{b}{a}\,(W-P) \qquad a \quad \frac{W-P}{P}\,b = \frac{W-P}{W}\,l$$
$$W = \frac{l}{b}\,P = \frac{l}{a}\,(W-P) \qquad b = \frac{P}{W}\,l = \frac{P}{W-P}\,a$$

Lever of the Third Class. In this the applied force P is between the weight lifted or resultant force

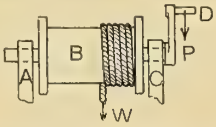


W and the fulcrum R. The following proportions and equations apply to this case:

$$P : W :: l : a \quad \text{or} \quad P\,a = W\,l$$
$$(P-W) : W :: b : a \quad \text{or} \quad (P-W)\,a = W\,b$$
$$(P-W) : P :: b : l \quad \text{or} \quad (P-W)\,l = P\,b$$
$$P = \frac{l}{a}\,W = \frac{l}{b}\,(P-W) \qquad a = \frac{W}{P}\,l = \frac{W}{P-W}\,b$$
$$W = \frac{a}{l}\,P = \frac{a}{b}\,(P-W) \qquad b = \frac{P-W}{W}\,a = \frac{P-W}{P}\,b$$

An ordinary crowbar, a pair of scissors, an air pump lever, are all examples of a lever of the first class. A pair of nut crackers, an oar (the water being the fulcrum), and often many of the levers about the starting and drain gear of an engine, are examples of a lever of the second class. The forearm (the elbow being the fulcrum), or a ladder when raised against a house, are examples of a lever of the third class.

Windlass and Crank. In this device a barrel B is carried on an axle supported in bearings at A and C, and operated by a crank D. The weight W may then, by means of a rope wound on the barrel, be raised or

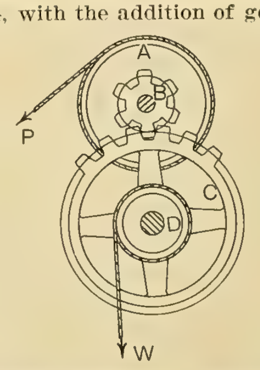


lowered by the action of a force P applied at the crank. The following proportions and equations give the relations between the various quantities concerned:

$$P : W :: r : R \text{ or } P\,R = W\,r$$
$$P = \frac{r}{R}\,W \qquad W = \frac{R}{r}\,P$$
$$r = \frac{P}{W}\,R \qquad R = \frac{W}{P}\,r$$

r = radius of barrel.
R = radius of crank.

Geared Hoist. This device is similar to those of Figs. 53 and 54, with the addition of gearing between



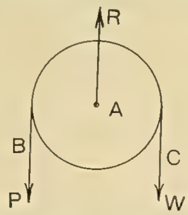
the force P and the weight W. The following equations apply to this case:

$$\frac{P}{W} = \frac{r_1\,r_2}{R_1\,R_2}$$
$$P = \frac{r_1\,r_2}{R_1\,R_2}\,W$$
$$W = \frac{R_1\,R_2}{r_1\,r_2}\,P$$

Most deck winches are illustrations of a simple geared hoist.

R_1 = radius of A
r_1 = radius of B
R_2 = radius of C
r_2 = radius of D

Single Fixed Pulley. A is a pulley or sheave supported from R and turning about its center. B C is a single rope led over the pulley, to one end of which the

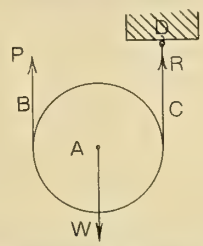


force P is applied, and to the other end of which the weight W is attached. The following equations apply to this case:

$$P = W$$
$$R = P + W = 2P$$
$$\text{Velocity of } W = \text{velocity of } P$$

A single whip used for raising light weights is an illustration of this purchase.

Single Movable Pulley. A is a pulley or sheave to the frame of which is attached the weight W. B C is the rope rove through the sheave, having one end

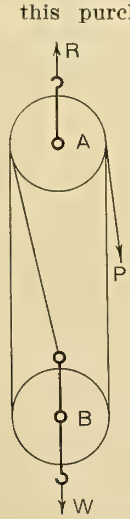


made fast to the support D, while to the other is applied the force P. The following equations apply to this case:

$$W = 2P$$
$$R = P = \frac{W}{2}$$
$$\text{Velocity of } W = \text{1-2 velocity of } P$$

Tacks and sheets on light sails are illustrations of this form of purchase.

Luff Tackle. In this purchase there are two



sheaves at A and one at B, and the rope is led as shown. The following equations apply to this case:

$$W = 3P$$
$$R = 4P$$

If upper block is fixed,

Velocity of W = 1-3 velocity of P.

If lower block is fixed,

Velocity of R = 1-4 velocity of P.

In order to obtain the greatest advantage with this purchase, therefore, B should be the fixed block.

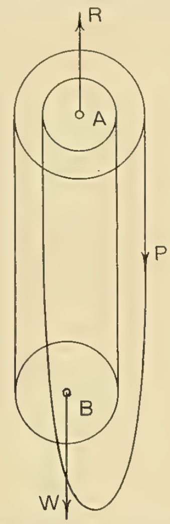
A Pair of Blocks, as in the Luff Tackle Figure, with Any Number of Sheaves in Either Block.

$\frac{W}{P}$ = total number of ropes at the lower block, passing through and attached.

$\frac{R}{P}$ = total number of ropes at the upper block, passing through and attached.

Thus in the figure the number of ropes at the lower block is 3 and at the upper block 4, which, according to the rule, would give the same relations between P R and W as in the equations above.

Differential Pulley. In this purchase there are two sheaves at A fastened together, or made in one



piece, and one sheave at B. A rope or chain is rove as shown in the figure, and the force is applied at P while the weight W is supported from the lower block. The following equations apply to this case:

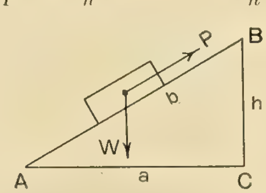
R = radius of larger upper pulley
r = radius of smaller upper pulley

$$\text{Then} \quad \frac{W}{P} = \frac{2R}{R-r}$$
$$\text{or} \quad W = \frac{2R}{R-r} P$$
$$\text{Velocity of } W = \frac{R-r}{2R} (\text{velocity of } P)$$

The differential pulley is commonly found in all engineers' outfits on board ship.

Inclined Plane.

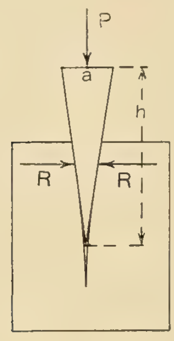
$$\frac{W}{P} = \frac{b}{h} \text{ or } W = \frac{b}{h} P$$



$$\text{and } P = \frac{h}{b} W$$

WEDGE.

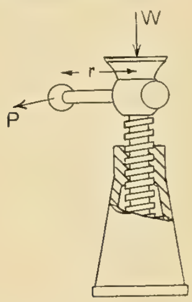
$$\frac{R}{P} = \frac{h}{a} \text{ or } R = \frac{h}{a} P$$



$$\text{and } P = \frac{a}{h} R$$

SCREW.

p = pitch of screw
P = force applied at radius r
W = pressure exerted



$$P : W :: p : 2 \pi r$$
$$\text{or } P : W :: p : 6.2832\, r$$
$$\text{or } W = \frac{6.2832\, r}{p} P$$
$$P = \frac{p}{6.2832\, r} W$$

Examples of the applications of the three last figures will be too familiar to need special mention.

Examples in Mechanics.

We give below the solutions of a few simple examples as illustrations of the preceding principles of mechanics. In all cases the effects of friction are omitted.

(1) In a lever of the first class as shown, $a = 48$ and $b = 8$. With a pull P of 160 lb., what weight W can be raised?

$$W = \frac{a}{b} P = \frac{48}{8} \times 160 = 960 \text{ lb.}$$

(2) In a lever of the second class as shown, $l = 72''$ and $b = 12''$. What force P will be required to raise a weight W of 600 lb.?

$$P = \frac{b}{l} W = \frac{12}{72} \times 600 = 100 \text{ lb.}$$

(3) In a lever of the third class as shown, $l = 40''$ and $W = 30$ lb. Where must a force P of 80 lb. be located so as to maintain equilibrium?

$$a = \frac{W}{P} l = \frac{30}{80} \times 40 = 15''$$

(4) The dimensions of a windlass and crank as illustrated are as follows: Radius of crank = 14". Radius of barrel = 4 1-2". What weight can be raised with a force of 60 lb. applied at the crank?

$$W = \frac{R}{r} P = \frac{14}{4\frac{1}{2}} \times 60 = 186 \text{ 2-3 lb.}$$

(5) With a wheel and axle as illustrated, the diameter of the wheel is 6' and of the axle 10". What force P will be required to hoist a weight W of 600 lb.?

$$P = \frac{r}{R} W = \frac{5}{36} \times 600 = 83 \text{ 1-3 lb.}$$

(6) The dimensions of a geared hoist as illustrated are as follows: Diam. of $A = 24''$; number of teeth in $B = 16$; number of teeth in $C = 96$; diam. of $D = 10''$. What weight W can be hoisted if $P = 100$ lb.?

Since the diameters and radii of wheels are in the same ratio as their numbers of teeth, we have:

$$W = \frac{R_1 R_2}{r_1 r_2} P = \frac{12 \times 48 \times 100}{8 \times 5} = 1440 \text{ lb.}$$

(7) With a single movable pulley as illustrated, what weight can be raised with a pull P of 90 lb.?

$$W = 2P = 2 \times 90 = 180$$

(8) With a purchase as illustrated, what force P will be required to raise a weight W of 372 lb., and what will be the load at R?

$$W = 3P \text{ or } P = W \div 3 = 372 \div 3 = 124$$
$$R = 4P = 4 \times 124 = 496$$

(9) The dimensions of a differential pulley as illustrated are as follows: Larger diameter, 13"; smaller diameter, 11". With a pull P of 80 lb., what weight W can be raised?

$$W = \frac{2R}{R - r} P = \frac{2 \times 6\frac{1}{2} \times 80}{6\frac{1}{2} - 5\frac{1}{2}} = 1040 \text{ lb.}$$

(10) An inclined plane as illustrated has dimensions as follows: Slant length, $b = 72''$; height, $h = 18''$. With a pull P of 40 lb., what weight W can be moved up the plane?

$$W = \frac{b}{h} P = \frac{72}{18} \times 40 = 160 \text{ lb.}$$

(11) A wedge as illustrated has the following dimensions: Back, $a = 4''$; length, $h = 26''$. What resistance R can be overcome by a force P of 216 lb.?

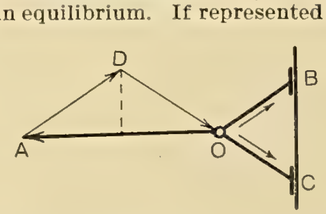
$$R = \frac{h}{a} P = \frac{26}{4} \times 216 = 1404 \text{ lb.}$$

(12) A screw as illustrated has the following dimensions: Pitch p = 1-4"; radius $r = 12''$; force $P = 60$ lb. What pressure W can be exerted?

$$W = \frac{6.2832 \times 12 \times 60}{\frac{1}{4}} = 18095.6$$

(13) Given a boiler brace $O\,A$ with crowfoot or forked attachment to the plate $B\,C$. With a known load on $O\,A$, required the load on $O\,B$ and $O\,C$.

Evidently the three forces on $O\,A$, $O\,B$ and $O\,C$ keep the joint O in equilibrium. If represented according to

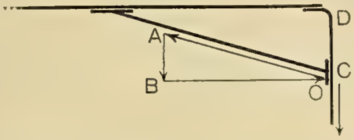


the polygon of forces [12] (5), they must form a closed triangle. This is represented by $O\,A\,D$, where $O\,A$ represents the force on the brace, $A\,D$ that on $O\,B$ and $D\,O$ that on $O\,C$. Hence if $C\,A$ is laid down to some convenient scale to represent the load on the brace, then $A\,D$ and $D\,O$ respectively will, according to the same scale, represent the loads on $O\,B$ and $O\,C$.

(14) Given a boiler brace $O\,A$ oblique to the shell $C\,D$. With a known load in the direction $B\,O$, required the load on $O\,A$.

The point of attachment O is again maintained in equilibrium by the action of the three forces, one along

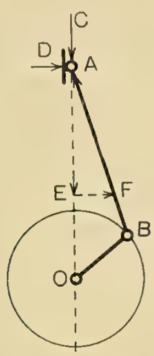
$O\ A$, one in the direction $B\ O$, and a third $O\ C$ existing as a tension in the plate. The triangle of forces in this case is represented by $O\ B\ A$. Hence if $O\ B$ is laid off



to any scale to represent the known load, then will $O\ A$ represent to the same scale the resulting load on the brace.

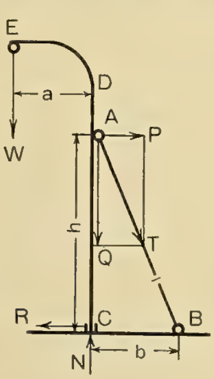
(15) Let $C\ A\ B\ O$ represent the moving parts of an engine. With a known piston load acting along $C\ A$, required the resultant loads on the connecting rod and on the guide.

The point A is kept in equilibrium by the action of the three forces, one acting down along $C\ A$, one acting up the rod along $B\ A$ and one acting from the guide



along $D\ A$. It is the two latter which are required. The triangle of forces in this case is represented by $A\ E\ F$. Hence if $A\ E$ is laid off to represent to any convenient scale the known piston load, then to the same scale will $A\ F$ and $E\ F$ represent the loads on the connecting rod and crosshead respectively. It thus appears that the load on the connecting rod is in general greater than that on the piston rod, and that it is greater in the same ratio that any length $A\ F$ is greater than the corresponding distance $A\ E$.

(16) Let the diagram represent a davit $C\ D$ supporting a weight W and braced by a stay $A\ B$. With a



given weight W, required the tension on the stay and the forces at the foot of the davit.

The tension T may be represented by its two components P and Q, and the reaction at C by two components N and R. In this case we require the use of both conditions of equilibrium, and without giving all details we will simply write the equations and the resulting values of the forces.

Equating vertical forces $W + Q = N$

Equating horizontal forces $P = R$

Taking movements about C $W\ a = P\ h$

We have also $P = \frac{b}{l}\ T$

and $Q = \frac{h}{l}\ T$

From these equations we find:

$$P = \frac{a}{h}\ W$$

$$Q = \frac{a}{b}\ W$$

$$T = \frac{l\ a}{b\ h}\ W$$

$$R = \frac{a}{h}\ W$$

$$N = \left(\frac{a + b}{b}\right) W$$

(*Concluded.*)

HELPS FOR CANDIDATES FOR MARINE ENGINEERS' LICENSES—MATERIALS OF ENGINEERING CONSTRUCTION—I.

BY DR. WILLIAM FREDERICK DURAND.

§1. ALUMINUM.

The commercially pure metal, i. e., with less than 1 per cent impurity, is white in color, soft, ductile, and malleable. It melts at about 1,160° F., has a tensile strength of about 15,000 lb. per square inch of section, but lacks in stiffness and *resilience*, or the power to withstand shocks.

Aluminum does not oxidize readily under the influence of ordinary air, but when in contact with sea-water, or in air charged with sea-water, the corrosion is often serious in extent. Aluminum cannot be welded except electrically, is not suitable for forging or rolling when hot, and cannot be tempered or hardened. It is, however, suitable for casting, and when cold can be rolled into sheets and drawn into wire, and in thin sheets or small pieces may be spun or flanged, or worked under the hammer in various ways.

Aluminum unalloyed is of comparatively small value to the engineer, but it enters into several valuable alloys as described in Section 9, and its use in this way has increased to a considerable extent within the past few years.

§2. ANTIMONY.

The pure metal is whitish in color, quite brittle and crystalline or laminated in structure, and has a melting point of about 840° F. It is useless in the pure state for ordinary engineering purposes, but is a valuable ingredient of various alloys used for bearing metals, etc., as described in Section 9.

§3. BISMUTH.

The pure metal is light red in color, very brittle and highly crystalline in structure, with a melting point of about 510° F. It is useless in the pure state for engineering purposes, but forms a part of various alloys used for bearing metals, etc., as described in Section 9.

§4. COPPER.

In the pure state the metal is red in color, soft, ductile, and malleable, with a melting point of about 2,000° F., and a tensile strength of from 20,000 to 30,000 lb. per square inch of section. Copper is not readily welded except electrically, but, on the other hand, is readily joined by the operation of brazing. Attempts have been made to temper or harden it, but the operation has not been made a practical success. It is readily forged and cast, and when cold may be rolled into sheets or drawn into wire, and in sheets or small pieces may be spun or flanged or worked under the hammer in various ways.

The tensile strength of copper rapidly falls off as the temperature rises above about 400° F., so that at from 800° to 900° the strength is only about one-half what it is at ordinary temperatures. This peculiarity of copper should be borne in mind when it is used in places where the temperature is liable to rise to these figures. Again, if copper is raised nearly to its melting point in contact with the air it readily unites with oxygen and loses its strength in large degree, becoming when cool crumbly and brittle. Copper in this condition is said to have been *burned*. The possibility of thus injuring the tenacity of copper is of the highest importance in connection with the use of brazed joints in steam pipes.

In the operation of brazing a joint, the surfaces to be joined are cleaned, bound together with wire or otherwise, then supplied with brazing solder in small bits mixed with borax as a flux, and placed in a clear fire until the solder melts and forms the joint. The brazing solder, or *hard solder*, as it is often called, is usually a brass or alloy of copper and zinc. The melting point of all such alloys is below that of copper, and when copper is joined to brass, or two pieces of brass are joined together, the solder used must have a melting point lower than either of these metals. In the operation of brazing a copper joint, therefore, the greatest care must be taken in the selection of a solder and in attention to the fire, so that there may be no danger of *burning* the copper, and thus endangering the quality of the metal in the joint.

Copper unalloyed is used chiefly for pipes and fittings, especially for junctions, elbows, bends, etc. For large sizes the material is made in sheets, bent and formed to the desired shape and brazed at the seams. Small sizes are either made by the same general process or from solid drawn pipe, which may be bent as desired after drawing. Copper is also largely used as the chief ingredient of the various brasses and bronzes, as described in Section 9.

§ 5. IRON AND STEEL.

Classification.

It will be convenient to give here a general classification of iron and steel products based on the methods of manufacture. The following is the classification used by Prof. J. B. Johnson in his text book on the *Materials of Construction*.

Iron and Steel.

MALLEABLE.

Wrought Iron.—Rolled or forged from a puddle ball; it contains slag and other impurities and cannot be hardened by sudden cooling.

Steel.—Rolled or forged from a cast ingot and free from slag and similar matter.

Soft Steel.—Will weld (with care), and cannot be hardened by sudden cooling. It is sometimes called *ingot iron*, and has the same uses as wrought iron.

Medium Steel.—Welds imperfectly except by electricity. Will not harden by sudden cooling.

Hard Steel.—Will not weld. Hardens by sudden cooling. Tool steel, etc.

SEMI-MALLEABLE.

Steel Castings.—Malleable metal cast into forms.

Malleable Cast Iron.—Non-malleable metal cast into forms, and then brought to a semi-malleable condition.

NON-MALLEABLE.

Cast Iron; Hard Cast Steel.—In describing these products at length we shall find it convenient to begin with cast iron.

[1] CAST IRON. This material consists of a mixture and combination of iron and carbon, with other substances in varying proportions.

(1) *Influence of Carbon.* In the molten condition the carbon is dissolved by the iron and held in solution just as ordinary salt is dissolved by water. The mixture or combination of the two elements is thus entirely uniform. The proportion of carbon which pure melted iron can thus dissolve and hold in solution is about 3 1-2 per cent. If *chromium* or *manganese* is present also, the capacity for carbon is much increased, while with silicon, on the other hand, the capacity for carbon is decreased. In the various grades of cast iron the proportion of carbon is usually found between 2 per cent and 4.5 per cent.

Now, when such a molten mixture cools and becomes solid, there is a tendency for a part of the carbon to be separated out and no longer remain in intimate combination with the iron. The carbon thus separated or precipitated out from the iron takes that form known as *graphite*, and collects together in very small flakes or scales. The carbon which remains in intimate combination with the iron is said to be *combined*, while that which is separated out is usually called *graphitic*.

The qualities of cast iron depend chiefly on the proportion of total carbon and on the relative proportions of combined and graphitic carbon.

With a high proportion of graphitic carbon the iron is soft and tough, with low tensile strength, and breaks with a coarse grained dark or grayish colored fracture. In fact the substance in this condition may be considered as nearly pure iron with fine flakes of graphite entangled and distributed through it, thus giving to the iron a spongy structure. The iron thus forms a kind of continuous mesh about the graphite, which decreases the strength by reason of the decrease of cross-sectional area actually occupied by the iron itself. Such irons are termed *gray*.

As the relative proportion of graphitic carbon decreases and that of combined carbon increases, the iron takes on new properties, becoming harder and more brittle. Its tensile strength also increases to a certain extent, and the fracture becomes fine grained or smooth and whiter in color. When these characteristics are pronounced the iron is said to be *white*. When about half the carbon is combined and half separates out as graphite, the effect is to produce a distribution of dark spots or points scattered over a whitish field. Such irons are said to be *mottled*.

In a general way with a large proportion of total carbon there is likely to be formed a considerable amount of graphitic carbon, and hence such irons are usually gray and soft. With a large proportion of carbon also the iron melts more readily and its fluidity is more pronounced. As the proportion of total carbon decreases the cast iron approaches gradually the condition of steel, whose properties will be discussed in a later paragraph.

Of the special ingredients in cast iron the *combined carbon* is the one of greatest importance. It is that chiefly which by uniting with the iron gives it new qualities, and the principal influence of other substances lies in the effect which they may have on the proportion of this ingredient. As between graphitic and combined carbon, the former does not affect the quality of the iron itself, but acts *physically* by affecting the structure of the casting; while the latter, by entering into combination with the iron, acts *chemically* and produces a new substance with different qualities. The following percentages of combined carbon are recommended for qualities of iron as indicated:

	Proportion of Combined Carbon.
Soft cast iron	.10 to .15 of one per cent.
Greatest tensile strength	about .45 of one per cent.
Greatest transverse strength	about .70 of one per cent.
Greatest crushing strength	one per cent or over.

The proportions of combined and graphitic carbon are influenced by the rate of cooling, and by the presence or absence of various other ingredients. Slow cooling allows time for the separation of the carbon and thus tends to form graphitic carbon and soft gray irons. Quick cooling, or *chilling* in the extreme case, prevents the formation of graphitic carbon and thus tends to form hard, white irons.

In addition to *carbon*, small quantities of *silicon, sulphur, phosphorus, manganese* and *chromium* may be found in cast iron.

(2) *Influence of Silicon.* The fundamental influences of silicon are two. (a) It tends to expel the carbon from the combined state and thus to decrease the relative proportion of combined carbon and increase that of graphitic carbon. (b) Of itself silicon tends to harden cast iron and to make it brittle.

These two influences are opposite in character, since an increase in graphitic carbon softens the iron. In usual cases the net result is a softening of the iron, an increase in fluidity, and a general change toward those qualities possessed by iron with a high proportion of graphitic carbon. This applies with a proportion of silicon from 2 per cent to 4 per cent. With more than this the influence on the carbon is but slight and the result on the iron is to decrease the strength and toughness, giving a hard but brittle and weak grade of iron.

A *chilled* cast iron is an iron which if cooled slowly would be gray and soft, but, as explained in (1), by sudden cooling, from contact with a metal mould or other means, becomes white and hard, especially at and near the surface. Certain grades of cast iron tend to chill when cast in sand moulds. This property is usually undesirable. In such cases the tendency can be prevented by the addition of silicon, which, by forcing the carbon into the graphitic state on cooling, prevents the formation of the hard, chilled surface. In all cases the actual effect of adding silicon will depend much on the character of the iron used as a base, and only a statement of the general tendencies can here be given.

To sum up, a white iron which would give hard, brittle and porous castings can be made solid, softer and tougher by the addition of silicon to perhaps 2 per cent to 3 per cent. As the silicon is increased the iron will become softer and grayer and the tensile strength will decrease. At the same time the shrinkage will decrease, at least for a time, though it may increase again with large excess of silicon. The softening and toughening influence, however, will only continue so long as additional graphite is formed, and when most of the carbon is brought into this state the maximum effect has been produced, and any further addition of silicon will decrease both strength and toughness.

(3) *Influence of Sulphur.* Authorities are not in entire agreement as to the influence of sulphur on cast iron, some believing that it tends to increase the proportion of combined carbon, while others maintain that it tends to decrease both the combined carbon and silicon. It is generally agreed, however, that in proportions greater than about .15 to .20 of 1 per cent it increases the shrinkage and the tendency to chill, and decreases the strength. Sulphur does not, however, readily enter cast iron under ordinary conditions, and its influence is not especially feared. An increase in the proportion of sulphur in cast iron is most likely to result from an absorption of sulphur in the coke during the operation of melting in the cupola.

(4) *Influence of Manganese.* This element by itself decreases fluidity, increases shrinkage, and makes the iron harder and more brittle. It combines with iron in all proportions. With manganese less than one-half, the combination is usually called *spiegeleisen.* With manganese more than one-half it is called *ferromanganese.* One of the most important properties of manganese in combination with iron is that it increases the capacity of the iron for carbon. Pure iron will only take about 3 1-2 per cent of carbon, while with the addition of manganese the proportion may rise to 6 per cent or 7 per cent. Manganese is also believed to decrease the capacity of iron for sulphur, and to this extent may be a desirable ingredient in proportions not exceeding 1 per cent to 1 1-2 per cent.

(5) *Influence of Chromium.* This substance is rarely found in cast iron, but it has the property, when present in large proportion, of raising the capacity of the iron for carbon from about 3 1-2 per cent up to about 12 per cent.

(6) *Shrinkage of Cast Iron.* At the moment of hardening, cast iron expands and takes a good impression of the mould. In the gradual cooling after setting, however, the metal contracts, so that on the whole there is a shrinkage of about 1-8 in. per foot in all directions, though this amount varies somewhat with the quality of the iron and with the form and dimensions of the pattern. In a general way hardness and shrinkage increase and decrease together.

(7) *Strength and Hardness of Cast Iron.* The hardness of cast iron is chiefly dependent on the amount of combined carbon, as noted above in (1).

The strength is also chiefly dependent on the same ingredient. As shown in (1), the greatest crushing strength is obtained with sufficient combined carbon to make a rather hard, white iron, while for the maximum transverse or bending strength the combined carbon is somewhat less and the iron only moderately hard, and for the greatest tensile strength the combined carbon is still less and the iron rather soft. Metal still softer than this grade works with the greatest facility, but is deficient in strength.

Numerical values for the strength will be given at a later point.

(8) *Uses of Cast Iron in Marine Engineering.* Cast iron is used for cylinders, cylinder heads, liners, slide valves, valve chests, and connections, and generally for all parts having considerable complexity of form. It is also used for columns, bed plates, bearing pedestals, caps, etc., though cast and forged steel are to some extent displacing cast iron for some of these items. It is also used for grate bars, furnace door frames, and minor boiler fittings, and for a great variety of special purposes usually connected with the stationary or supporting parts of machines.

(9) *Inspection of Castings.* In the inspection of castings care must be had to note the texture of the surface, and to this end the outer scale and burnt sand should be carefully removed by the use of brushes, or chipping hammer, or, if necessary, by pickling in dilute muriatic acid. The flaws most liable to occur are blow holes and shrinkage cracks. The latter, however, are not often met with when the moulding and casting are properly carried out. The parts of the casting most liable to be affected by blow holes are those on the upper side or near the top. On this account a sinking head or extra piece is often cast on top, into which the gases and impurities may collect. This is afterward cut off, leaving the sounder metal below.

The presence of blow holes, if large in size or in great number and near the surface, may often be determined by tapping with a hand hammer. The sound given out will serve to indicate to an experienced ear the probable character of the metal underneath.

(10) *Special Operations on Cast Iron.* Cast iron may be softened and toughened by the process of malleablizing, as described in [2]. It may be somewhat hardened on the surface by arresting the usual process of malleablizing at a suitable point and then hardening as for steel. This operation arrested before completion results in the formation of a surface layer of material having essentially the properties of steel.

Cast iron may be brazed to itself or to most of the common structural metals by the use of a brazing solder of suitable melting point, and with proper care in the operation. Cast iron may also be united to itself or to wrought iron or steel by the operation of burning. This consists in placing in position the two pieces to be united, and then allowing a stream of melted cast iron to flow over the surfaces to be joined, the adjacent parts being protected by fire clay or other suitable material. The result is to soften or partially melt the surfaces of the pieces, and by arresting the operation at the right moment they may be securely joined together.

ELECTRICITY ON BOARD SHIP—PRINCIPLES AND PRACTICE.—XVI.

BY WM. BAXTER, JR.

Switch Board Instruments.

The instruments commonly used upon switch boards are: switches, circuit breakers, ammeters, voltmeters, lightning arresters, safety fuses and field regulating rheostats. Of these the first named will demand our attention in the present article.

A switch, properly defined, is any device by means of which a current may be diverted into any circuit, or be cut off therefrom entirely. Switches may be divided according to the manner in which they are moved, and thus we would obtain side throw switches, plunger switches and vertical throw, or knife blade, switches. A side throw switch in its simplest form is shown in Figs. 70 and 71, the first being a top view

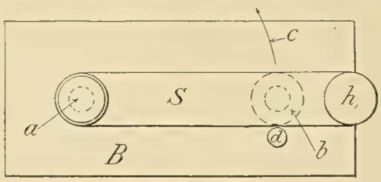


FIG. 70.

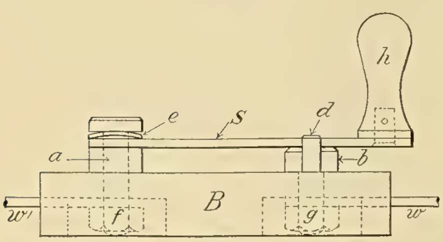


FIG. 71.

and the second a side elevation. In both these illustrations, *B* is the base, and it is made of hard wood or hard rubber for small sizes that are intended to transmit weak currents, and of slate or marble for those of larger capacity. The part marked *S* is the switch blade, and it is provided with a handle *h*, which latter is well insulated from other parts. The terminals of the line are connected with the studs *a* and *b*, as is shown in Fig. 71, where *w w* are the wires, which are firmly held by the nuts *f* and *g*.

Switches of this kind are generally arranged to move in one direction only, as is indicated by arrow *C*, and to prevent movement in the other direction the stop post *d* is provided. This construction is advantageous, as with it the switch can be closed rapidly without

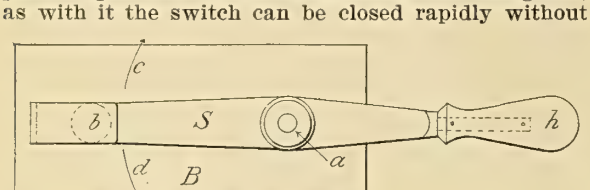


FIG. 72.

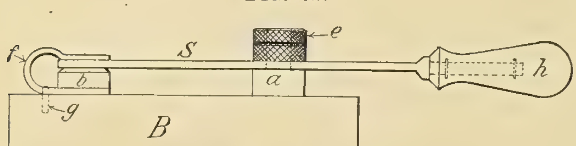


FIG. 73.

danger of swinging it beyond the closed position. In the illustrations the switch is shown closed, and in this position it can be seen that the current will pass from *a* to *b* through the switch blade *S*. If the blade is raised in the direction of arrow *C* the circuit will be opened. When the switch is closed it is necessary that the blade rest firmly upon the stud *b*, and to render this certain a spring washer is provided at *e*, Fig. 71, and *S* is set so that it must spring up slightly to pass over *b*.

Another modification of the simple side throw switch is shown in Figs. 72 and 73, these being top and side views, respectively. The difference between this and the former design is that the swiveling point is transferred from the end to the center of the switch blade. With this construction it would be easy for the blade to be raised from *b* by a downward pressure of the hand of the operator, and to avoid any trouble from such an occurrence the spring *f* is provided. This spring serves to hold the blade down, but even if it should be raised, no damage would be done, as *f* and *b* are electrically connected, therefore the current would pass from *S* to *f* and thus to *b*. The spring is provided so as to keep *f* in place. As the frequent movement of *S* around *a* would tend to loosen the nuts *e*, these are made double—that is, a nut and a check nut are used—and, except for small switches, a spring washed as *e* in Fig. 71 is also provided. The switch shown in these two figures is made so as to swing in both directions, but it can also be made to have but a single direction of motion.

In Fig. 74 is shown a switch that can be used for two purposes, one to connect one terminal of a line with

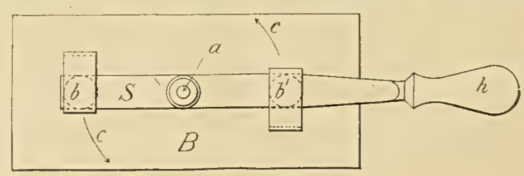


FIG. 74.

two wires, and the other to open or close the circuit at two points at the same time. If the center stud *a* is connected with one terminal of the line, and *b b'* are connected with separate wires, then it can be readily seen that when the switch blade is moved to the closed position as shown in the figure, the current entering through the wire connected with *a* will divide and pass out through the two wires connected with *b* and *b'*. If one end of the line wire is connected with *b* and the other with *b'*, then if the switch blade is moved in the direction of arrows *C* there will be a break in the circuit between *S* and *b'* and another one between *S* and *b*, hence two points in the circuit will be opened at the same time.

The switch shown in Fig. 75 can be used to connect one wire with four, or it can be used to produce four

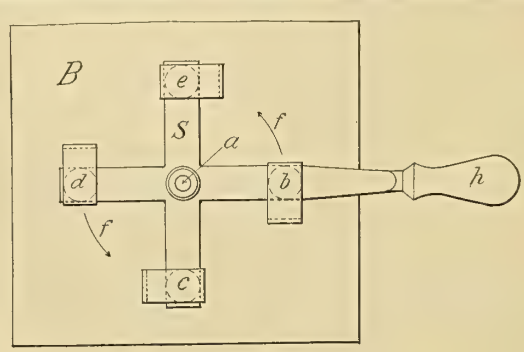


FIG. 75.

breaks in the same circuit, but to accomplish this last result it would have to be slightly modified in so far as the blade construction is concerned, as will be shown hereafter. If one wire is connected with the center stud *a*, four wires can be fed from the four studs *b c d e*, and all can be connected or disconnected at the same time by the movement of a single handle *h*.

Side throw switches are used almost exclusively for small currents, as, for example, for connecting the voltmeters with the circuit. For large currents the knife blade type of switch is the one universally adopted.

Switches are designated not only according to their form, but also according to the operations they perform; thus we have single and double pole switches, single and double break switches, single and double throw switches, etc. Nearly all these types of switches are made, as a rule, of knife blade design, although the side swing type is also used to a limited extent. Diagrams that represent the latter design, are, however, more simple, and show more clearly the operations performed by the different types, therefore we will use them in the following explanations.

Diagram Fig. 76 represents what is called a single-throw single-break switch. It is called a single-throw

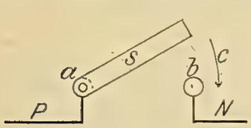


FIG. 76.

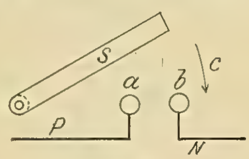


FIG. 77.

switch because the movement of *S* can only open or close a single circuit—that is, the terminals *a* and *b* of the line wires *P* and *N* can be connected when *S* is moved down in the direction of arrow *C*. If *S* is arranged to move in either direction, as in Fig. 72, the switch will still be single throw. The switch is designated as single-break because when it is opened it only breaks the circuit at one point, between *b* and *S*.

Diagram Fig. 77 represents a single-throw double-break switch, and it will be noticed that the difference between it and Fig. 76 is that *S* is not pivoted at *a*, hence when it is in the open position *S* is entirely disconnected from the circuit. When *S* is lowered it connects *a* with *b*, and when it is raised from this position two breaks are made in the circuit, one between *S* and *a* and one between *S* and *b*.

Diagram Fig. 78 is a single-throw quadruple-break switch. When *S* is moved in the direction of arrow *e*

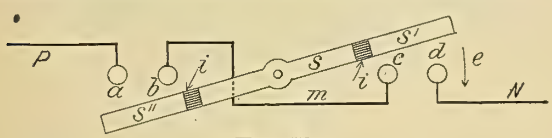


FIG. 78.

the ends *S'* and *S''*, which are insulated from *S* and from each other, connect wires *P* and *N* by closing the circuit between *a* and *b* and also between *c* and *d*. When *S* is moved upward the circuit is opened at four points, between *a* and *S''*, *S''* and *b*, *c* and *S'*, *S'* and *d*. It can be seen at once that if the switch lever *S* is made with more insulated sections, such as *S'* and *S''*, and each one of these connects two points, then the number of breaks can be increased; hence, a switch can be constructed with any number of breaks, therefore we can divide them into single and multiple break switches. In practice more than four breaks are seldom used. The object of introducing a number of breaks is to reduce the size of the spark produced when the switch is opened. If two breaks are used, there will be two sparks, but each one will be less than one-half the size of the single spark obtained with a single break. With four breaks there will be four sparks, but each one will be much less than one-fourth the size of the single spark. Switches with multiple breaks are used only with currents of high voltage, or high voltage and strength combined. For a very strong current with low voltage the single break acts well enough, as the spark produced when the switch is opened is short, the length of the spark being dependent upon the voltage.

Diagram Fig. 79 shows a double-throw single-break switch, and diagram Fig. 80 is a double-throw double-break switch. In these two figures it will be seen that

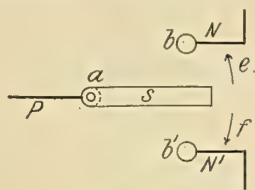


FIG. 79.

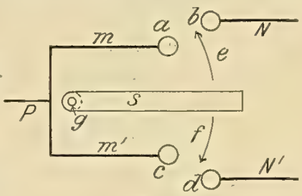


FIG. 80.

if *S* is moved in the direction of arrow *e*, wire *P* will be connected with wire *N*; and if it is moved in the direction of arrow *F*, *P* will be connected with *N'*; hence there are two directions in which the switch can be moved to close the circuit.

Diagram Fig. 81 shows a multi-throw single-break switch, and diagram Fig. 82 is a multi-throw double-break switch. In the first figure the wire *P* can be

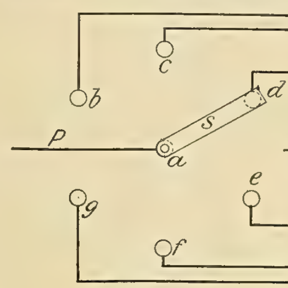


FIG. 81.

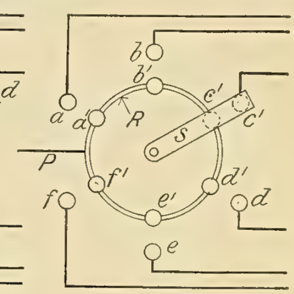


FIG. 82.

connected with any one of the six wires leading off from the contacts *b c d e f g* by the movement of *S*, but in each case the circuit is only opened at one point. In Fig. 82, however, wire *P* connects with all the contacts of the inner circle, these being joined by the ring *R*, and *S* is not directly connected with *P*, hence when it is moved so as to connect any two contacts it closes the circuit at two points, just as in the case of Fig. 77.

The switches so far explained are of the single pole type—that is, they open or close the circuit at one place only. The wire *P* in these diagrams may be considered as one of the leads coming from the generator. In Figs. 83 to 86 switches of the two pole type are

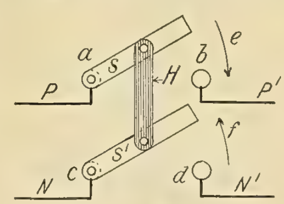


FIG. 83.

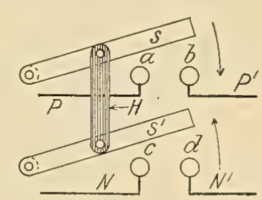


FIG. 84.

shown. In Fig. 83 the switch *S* connects *P* with *P'*, and switch *S'* connects *N* with *N'*. In Fig. 84 the two switches make the same connections, but the circuits are broken at two points, hence this switch is a two pole double-break single-throw switch, while Fig. 83 is a two pole single-break single-throw switch.

Diagrams Figs. 85 and 86 represent two pole double-throw switches, the first being single-break and the second double-break. In both cases movement in the direction of arrow *e* connects wire *P* with *P′* and *N* with *N′*, while movement in the direction of arrow *f* connects *P* with *P″* and *N* with *N″*. Fig. 85 is a single-

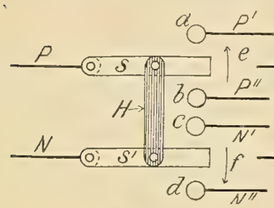


Fig. 85.

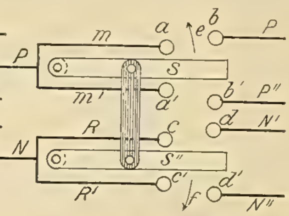


Fig. 86.

break and Fig. 86 is a double-break switch. The link *H* is a connection made of insulating material, and is provided so that the two switches may be moved together.

It can be readily seen that a switch can be made that will open or close the circuit in three or more wires just as well as in two, and also that the multi-throw arrangement of Fig. 81 can be applied to such switches. It can also be seen that the multi-break construction of Fig. 78 can be applied to any number of poles or any number of throws, hence we can have multipole, multi-throw, multi-break switches.

A single pole switch is one that opens or closes a single circuit. A multi-pole switch opens or closes more than one circuit. A single-throw switch can only connect one terminal with another terminal. A multi-throw switch can connect a single terminal with more than one opposite terminal. A single-break switch opens or closes the circuit at one point only. A multi-break switch opens and closes the circuit at more than one point.

Figs. 87 and 88 show two different types of reversing switches. In the first figure, if the movement is in

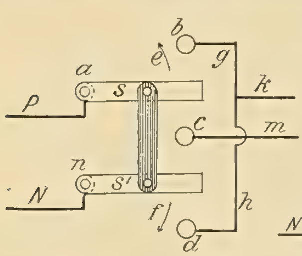


Fig. 87.

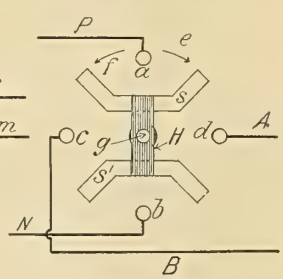


Fig. 88.

the direction of arrow *e*, *S* connects *P* with *k*, through wire *g*, and *S′* connects *N* with *m*. If the movement is in the direction of arrow *f*, *S* connects *P* with *m*, and *S′* connects *N* with *k*, through wire *h*. In Fig. 88, if the movement is in the direction of arrow *e*, *S* connects contacts *a* and *d*, while *S′* connects *b* and *c*, thus connecting wire *P* with *A* and wire *N* with *B*. If the movement is in the direction of arrow *f*, *S* connects *a* with *c* and *S′* connects *b* with *d*, thus connecting *P*

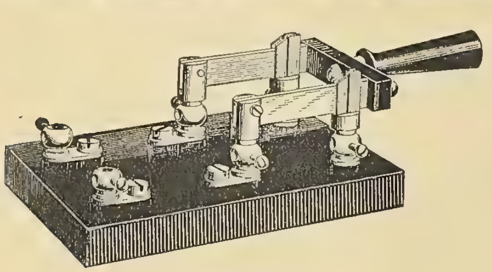


Fig. 89.

with *B* and *N* with *A*. The connection *H* is made of insulating material just as in Figs. 83 to 87.

Figs. 89 to 93 show actual forms of switches for currents of large capacity, this design being what is called the knife blade type. Fig. 89 is a double pole

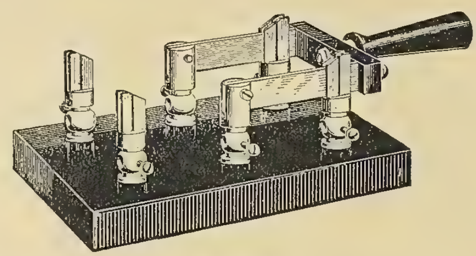


Fig. 90.

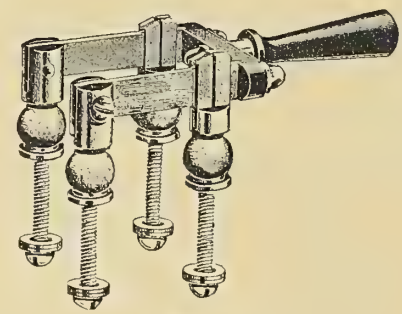


Fig. 91.

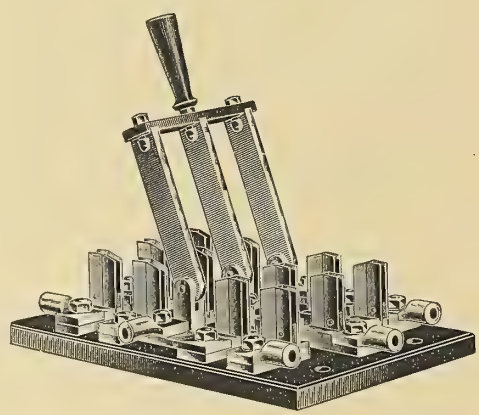


Fig. 92.

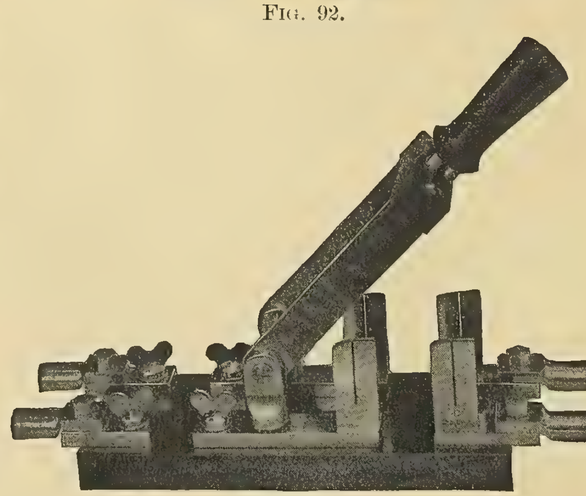


Fig. 93.

single-throw and single-break switch. Fig. 90 is a double pole double-throw single-break switch. Fig. 91

shows the parts of Fig. 89 removed from the base. The switches are furnished with a base for ordinary use, but for switch board purposes the parts are located directly upon the switch board face.

Fig. 92 illustrates a three pole double-throw double-break switch, and Fig. 93 is a two pole single-throw double-break switch. In all these designs the knife blades are insulated from each other, the handle and the cross bar being made of an insulating material.

The Navy Departments of the European powers are greatly exercised over the reported successful trials of the French submarine torpedo boat Gustave Zédé. A trial was recently carried out in which the boat made an attack on the French warship Magenta. During the trial the boat sank below the waves so rapidly that the gunners would in action have been unable to have struck her with projectiles, and she succeeded in landing her torpedo in a vulnerable place. After discharging the torpedo the boat appeared at a considerable distance off, in a direction different from that in which it was last seen before submersion. A larger boat is now being built which will be equipped with more powerful propelling machinery, and further and extensive trials will be made. The Gustave Zédé is operated by storage batteries, but the new boat will have steam engines as well.

ENGINEERS' DICTIONARY—XV.

Engine.—In the most general sense an *engine* may mean any apparatus used for producing some mechanical effect. In the *steam engine* the mechanical force arising from the elasticity and expansive action of steam is made available as a motive power. The marine steam engine may be classified in various ways according to the special features under consideration. The typical modern marine engine, Fig. 54, may be defined as a *vertical, inverted, direct-acting, multiple expansion, condensing,* engine. We will give briefly the significance of these various terms.

In the early days of marine engineering the engines were often horizontal, as shown in Figs. 55 and 56, and such are still met with occasionally in special types of warship practice and elsewhere. An intermediate type known as the inclined engine has also been used to a considerable extent with paddle wheels. (Fig. 57.)

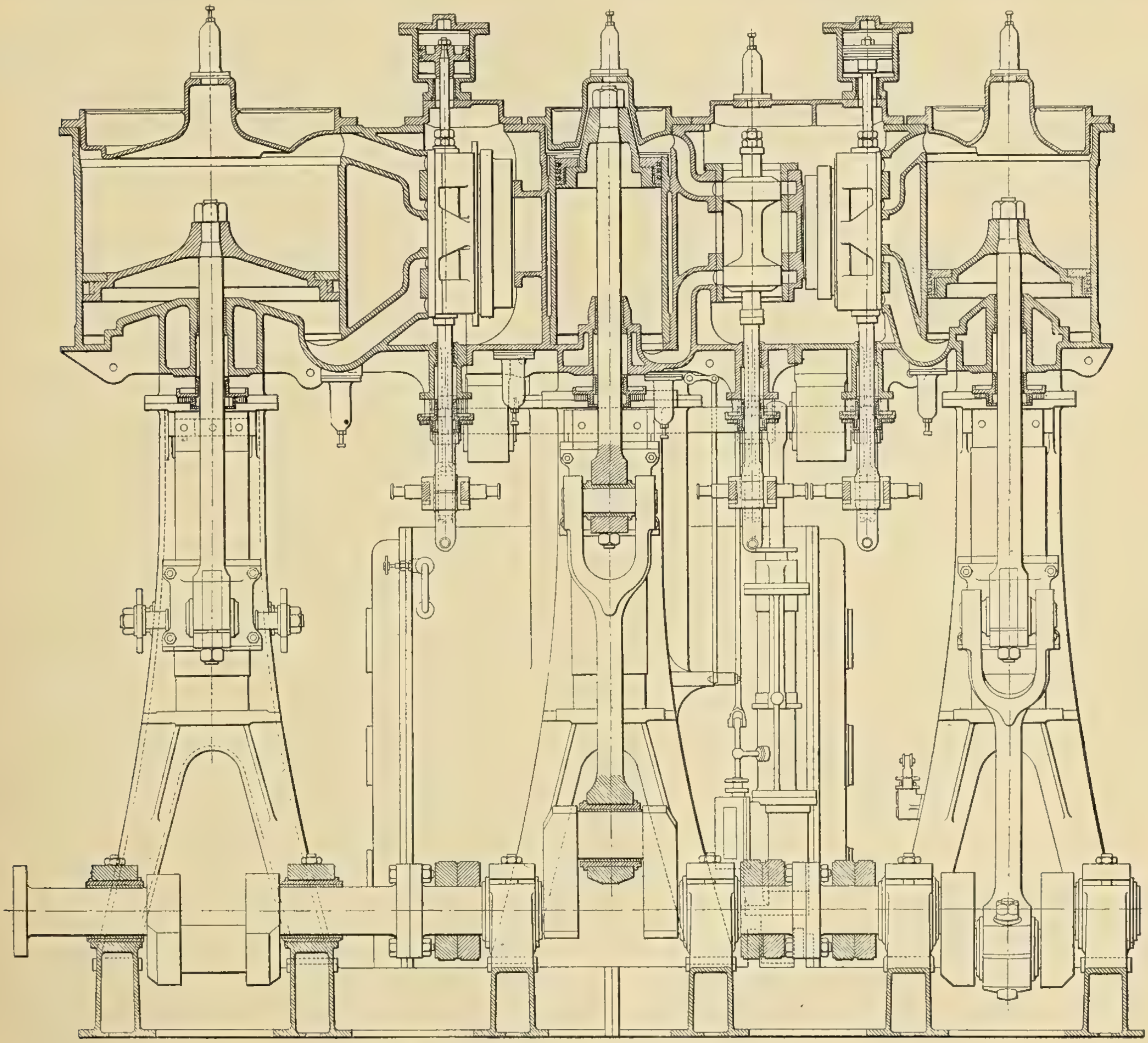


Fig. 54.—MODERN TRIPLE-EXPANSION ENGINE.

In modern practice with rare exceptions the marine screw engine is vertical, as in Fig. 54.

In the earlier vertical marine engines the cylinder was at the bottom and the motion of the parts proceeded upward either directly to the crank shaft as in the oscillating engine, Fig. 58, or to a beam or intermediate mechanism, whence it came back to the shaft. See Fig. 59. In the modern engine the cylinders are on top and the motion of the parts proceeds downward to the shaft. Hence in comparison with the earlier type the modern engine is called *inverted.*

Where the conecting-rod and crank lie beyond the crosshead or farther end of the piston rod, as in Fig. 54,

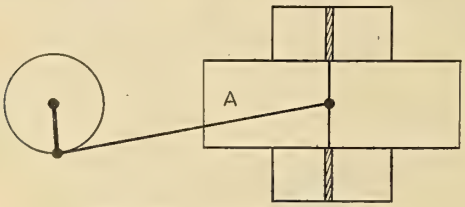


FIG. 55.—TRUNK ENGINE.

the engine is said to be *direct-acting.* In certain early types of horizontal engines in single-screw ships, as represented in Fig. 60, the cylinder was sometimes

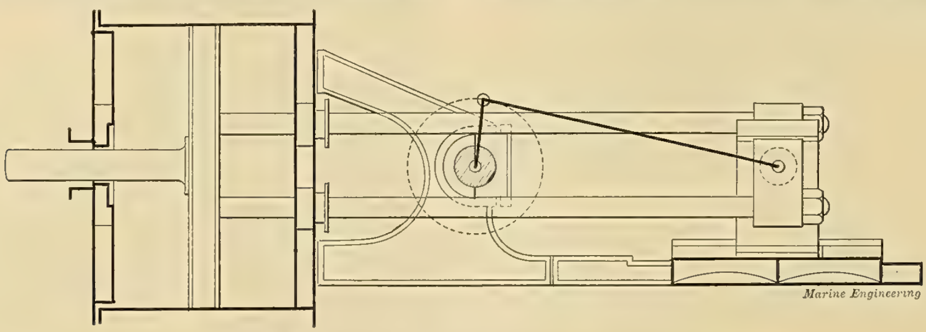


FIG. 60.—RETURN CONNECTING ROD ENGINE.

placed close to the shaft and two piston rods were fitted passing over beyond the shaft, one above and the other below. Then from a crosshead at this point the motion came back to the crank pin by a connecting-rod in the usual way. Such engines were called *return*

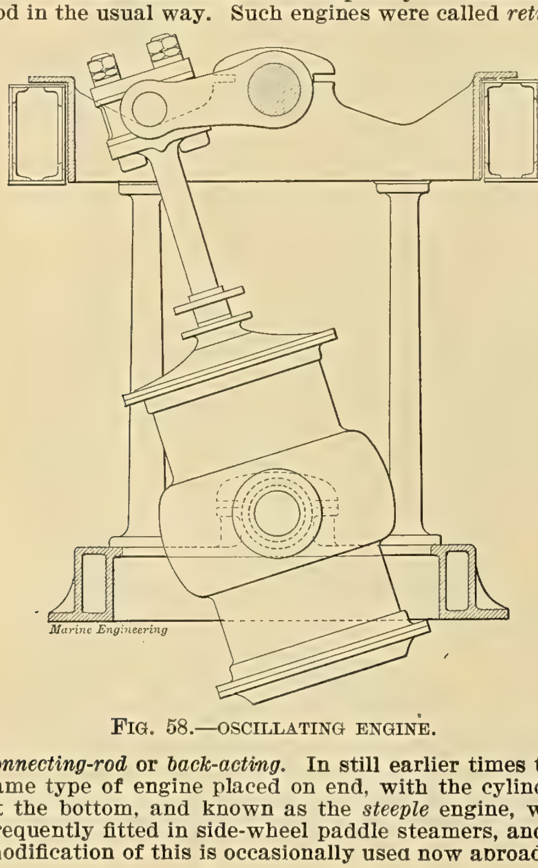


FIG. 58.—OSCILLATING ENGINE.

connecting-rod or *back-acting.* In still earlier times the same type of engine placed on end, with the cylinder at the bottom, and known as the *steeple* engine, was frequently fitted in side-wheel paddle steamers, and a modification of this is occasionally used now abroad.

In early marine engines the expansion of the steam always took place in one cylinder only. Such engines are termed *simple.* In the typical modern engine the steam is passed through a series of cylinders from one

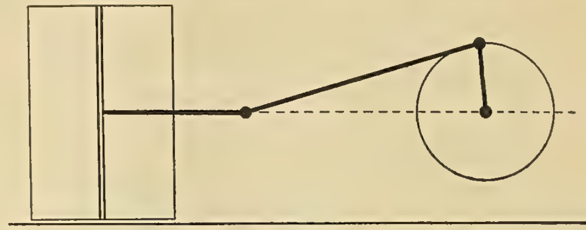


FIG. 56.—HORIZONTAL ENGINE.

to another of increasing size. Such engines in general are termed *multiple expansion.* If the steam is thus used successively in two cylinders or the expansion occurs in two stages, the engine is said to be a *compound;* if in three stages, it is a *triple* or *triple expansion;* if in four stages, it is a *quadruple* or *quadruple expansion,* etc.

Where the steam after being used in the cylinder is

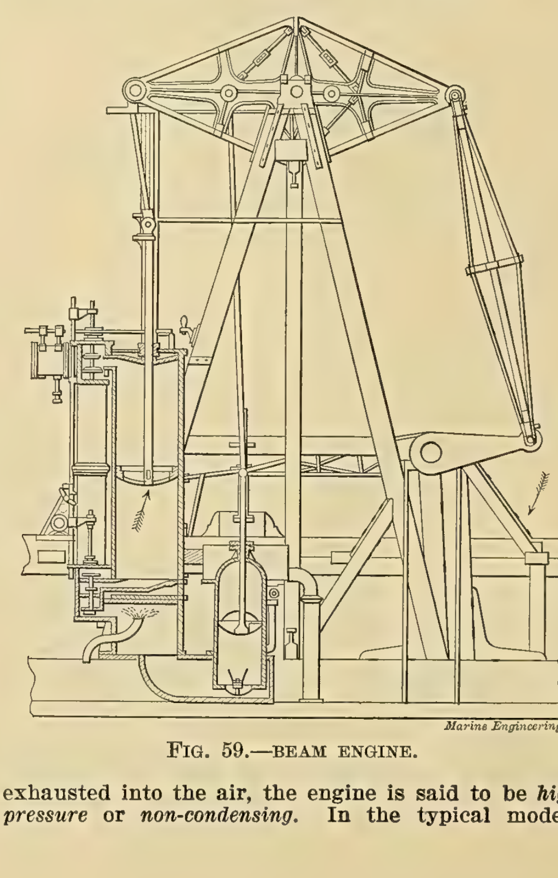


FIG. 59.—BEAM ENGINE.

exhausted into the air, the engine is said to be *high-pressure* or *non-condensing.* In the typical modern engine the steam is exhausted to a condenser, thus giving the advantages of an increased ratio of expansion and decreased back pressure. Such engines are called *condensing*.

Engines are often given special names according to the nature of the mechanical movements employed.

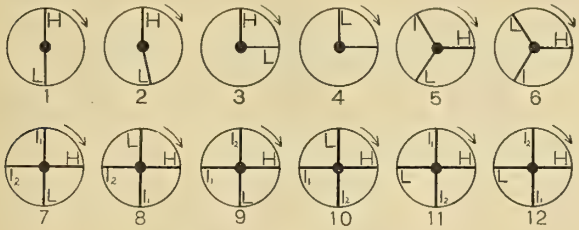


FIG. 62.—CRANK ANGLES.

In the usual type, as already noted,' the motion is direct-acting and proceeds through piston, piston-rod, crosshead, connecting-rod, crank pin and crank shaft. In the beam engine, as shown in Fig. 59, the motion passes from the piston-rod to a crosshead and then by

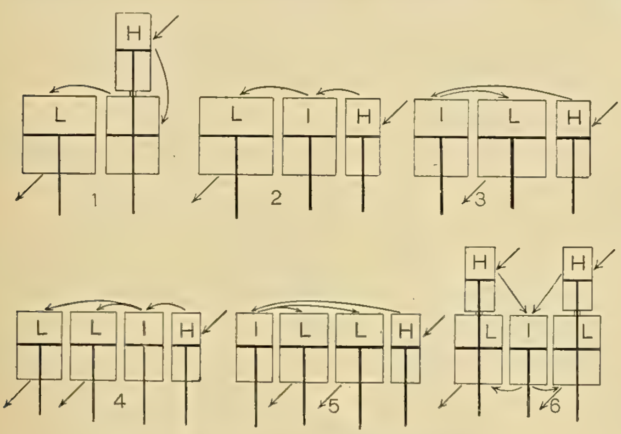


FIG. 63.—TRIPLE ARRANGEMENTS.

link or parallel motion to the beam. Thence from the other end of the beam it passes by the connecting-rod to the crank pin and crank shaft. Such engines are especially suited to side-wheel paddle steamers, and for many years have been considered the standard engine for use on river, bay and lake steamers. In more recent years, however, the vertical direct-acting engine and screw propeller are to a considerable ex-

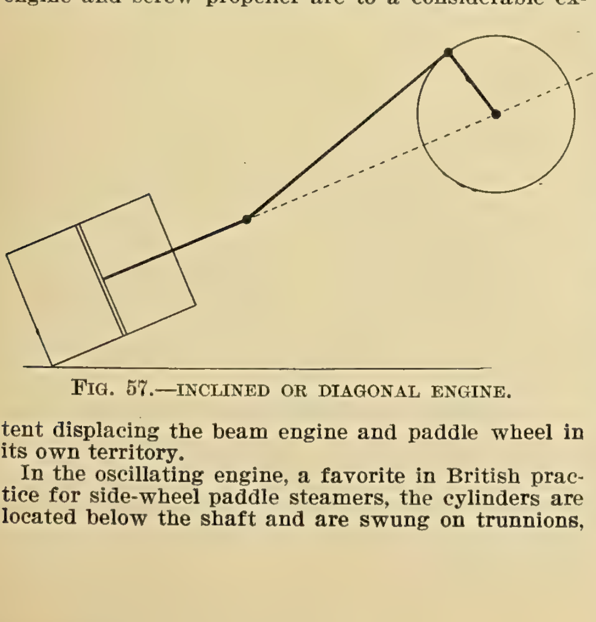


FIG. 57.—INCLINED OR DIAGONAL ENGINE.

tent displacing the beam engine and paddle wheel in its own territory.

In the oscillating engine, a favorite in British practice for side-wheel paddle steamers, the cylinders are located below the shaft and are swung on trunnions, as shown in Fig. 58. The piston-rod is connected directly to the crank pin, the piston-rod and connecting-rod forming thus but one member. This is made possible by the swinging of the cylinder upon its trunnions, as shown by the figure. The *trunk* type of horizontal engine, as shown in outline in Fig. 55, was often fitted in former years where economy of transverse or athwartship dimension was necessary. In

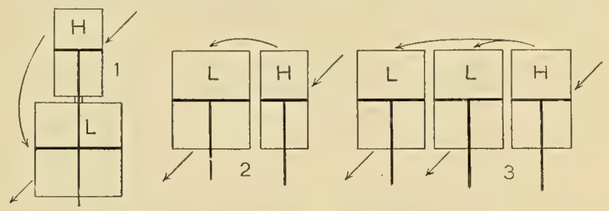


FIG. 61.—COMPOUND ARRANGEMENTS.

this engine the use of the piston-rod was avoided by the large trunk *A*, to which the connecting-rod was directly attached, as shown.

The stern-wheel western river boat engine is a direct-acting horizontal engine connected to the stern wheel, and provided with a peculiar type of valve gear. For full description see MARINE ENGINEERING, November, 1897.

In speaking of the principal parts of the modern

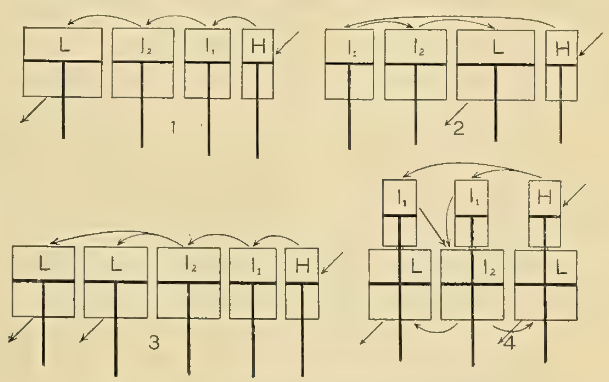


FIG. 64.—QUADRUPLE ARRANGEMENTS.

typical engine, we may note first the stationary and then the moving parts. The *cylinders* are at the top and consist each of a cylindrical chamber containing the moving piston which is forced by the steam alternately in one direction and then in the other. Attached to and part of the cylinder casting are the valve chests and connecting ports and passages. Within the valve chests are the valves, either flat or cylindrical themselves, which regulate the entrance and exhaust of steam at each end of the cylinder alternately. See also under the heading *Cylinder*. The cylinders rest on the columns, which are either of the inverted Y or of the cylindrical type, as described under the heading *Column*. The columns rest on the *bed-plate* (see under that heading), and this in turn rests on the *engine seating*, a part of the structure of the ship specially strengthened to carry the weight and extra stress which must be taken care of at this point.

Of the moving parts the *piston* is acted on by the steam and is forced alternately to and fro in the cylinder. The piston is carried by the piston-rod, at the lower end of which is the crosshead. Here by a pin joint connection the connecting-rod is attached. (See also under *Crosshead* and *Connecting-rod*.) At the lower end the connecting-rod contains the *crank pin*, and thus connection is made between the piston and the crank shaft, and the to-and-fro motion of the former is transformed into the rotary motion of the latter. From the crank shaft the rotary motion is transmitted directly through the line shaft to the propeller. The valves moving within the valve chests are driven by the *eccentrics* (see under that head) through one of the various forms of valve gear employed for marine engines.

Cylinders are usually made of cast iron; frames and columns of cast iron, cast steel or forged steel; bed plates of cast iron or cast steel; pistons of cast steel; piston-rods, connecting-rods and crank shafts of forged steel; crossheads of cast iron, cast steel or forged steel; valves of cast iron, and most other parts of the valve gear of forged steel.

The various members of a multiple-expansion marine engine may be arranged in a great variety of ways as regards the location of the cylinders, the crank angles, and the way in which the cranks follow each other around in the revolution. These are illustrated on the preceding page. Of the many combinations which might be made, only the more important are mentioned. Throughout these diagrams the high-pressure cylinder is denoted by H, the low-pressure cylinder by L, the intermediate cylinder of a triple-expansion engine by I, and the first and second intermediates of a quadruple-expansion by I_1 and I_2, respectively. Where the total cylinder volume is divided between two, each of half size, both of the latter are given the same letter. The course of the steam through the engine is also indicated by the arrows. For compound engines the usual arrangements are illustrated in Fig. 61. We may have two or three cylinders and one, two or three cranks. In the latter case the entire volume of low-pressure cylinder is divided between two cylinders, each of half the total volume. The first arrangement with high-pressure cylinder on top of low-pressure is known as a single-crank *tandem* compound, but is rarely met with in marine practice. The other arrangements may be placed, of course, with either end forward. The various crank angles are shown in Fig. 62 at 1, 2, 3, 4 and 5, the crank marked I in No. 5 being in this case for one of the L. P. cylinders. With two cranks the angle between may be either 90 deg. or 180 deg., or slightly greater or less than 180 deg., as 175 deg. or 185 deg. The 90 deg. angle is undoubtedly the best for all-around service. The 180 deg. angle gives a better balance to the moving parts and admits of a simplification of valve gear, and is sometimes preferred for these reasons. There is, however, a liability of the engine's sticking on the center and the general readiness of handling is less than with cranks at 90 deg. To overcome this, angles of 175 deg. or 185 deg., as shown at 2, are sometimes used, the balance of moving parts in such case being substantially as good as with an angle of 180 deg.

With three cranks the angles are usually equal, and hence 120 deg. each. Occasionally they are slightly varied from these valves in order to give a more uniform rotative effort, or to give a better balance to the forces causing vibration.

For the triple-expansion engine the more important arrangements of cylinders are shown in Fig. 63. We may have three cylinders or more, and two, three or more cranks. The most common types have either three or four cranks, in the latter case the total L. P. volume being divided between two cylinders, each of half the total volume. The crank angles are usually 120 deg. with three cranks, and 90 deg. with four, though occasionally slight variations from these valves are adopted in order to obtain a better balance of the forces causing vibration. Of the various arrangements of cylinders shown in Fig. 63, each may, of course, be placed either end forward in the ship. We may also have the various sequences and arrangements of cranks as indicated in Fig. 62, the changes of lettering where necessary being readily seen.

For the quadruple-expansion engine the more important cylinder arrangements are shown in Fig. 64. The number of cylinders may be four, five or six, with four or five cranks. With five cranks the angles are usually equal, and hence of 72 deg., though as with three and four cranks slight departures might be made to obtain a better balance of the forces producing vibration. The arrangements of cylinders shown in Fig. 64 may be placed in the ship either end forward, and various crank sequences in addition to those shown in Fig. 62 may be easily arranged. One of the chief tendencies of modern practice is to pay especial attention to the balancing of the forces producing vibration. The use of irregular crank angles in this connection has been already referred to. In addition, and of not less importance, the larger cylinders with the larger and heavier pistons are now frequently placed inside, with the lighter moving parts on the outside, as in Fig. 63, Nos. 3 and 5, or Fig. 64, No. 2.

Eduction Valve or Pipe.—The same as a discharge valve or pipe. The word *eduction* means *leading from or away*. Fig. 65 shows a side discharge valve for a steamship.

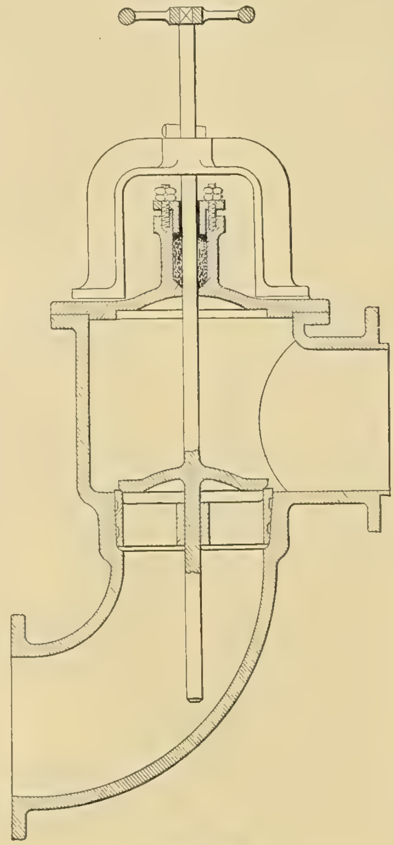


FIG. 65.

1899 Meeting of S. N. A. and M. E.

The following notice has been sent out by the Society of Naval Architects and Marine Engineers:

"The executive committee invites correspondence as to papers to be read at the seventh annual meeting in November next. It is necessary for intelligent discussion that papers should be in print thirty days before the meeting, and, therefore, members who desire to submit papers or who have suggestions to make are requested to communicate with the secretary at their earliest convenience.

"The following resolution was unanimously adopted at the sixth annual meeting:

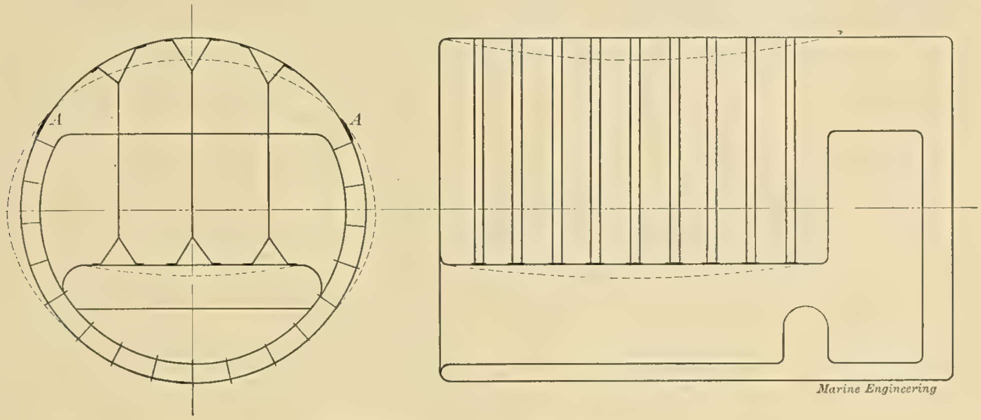
" 'That papers be invited upon the subject of life-saving at sea for the next annual meeting, and that two such papers be selected by the executive committee for publication and discussion.'

"Members are invited to suggest names of persons outside the society who might be asked to prepare papers on this subject."

QUERIES AND ANSWERS.

Communications intended for this department will not receive attention unless accompanied by the full name and address of the sender, which will be considered confidential.)

Q.—I send a sketch of a boiler which collapsed at 160 lb. pressure, as shown in the dotted lines, while undergoing the hydrostatic test. The boiler was built of 60,000 lb. T. S. steel, and was 6 ft. 6 in. dia. and 11 ft. long. The circular seams were single riveted and the longitudinal seams double riveted. The bracing between the shell and crown sheet was "crow foot," and no angle scantling was used in the construction. As shown in the sketch the crown sheet came down 1 in., the top of the boiler 2 in., and each side bulged out 1 in. The rivets broke in the longitudinal seams. The boiler was built exactly in accordance with the U. S. inspection rules for 135 lb. steam pressure. I would like to know if it was properly braced. U. S.



DIAGRAMS OF COLLAPSED BOILER.

A.—The distortion of the boiler as described in your letter and shown in the sketch is just what might be expected from the circumstances of the case, and if the boiler was built and braced according to U. S. rules it proves either that the rules are not correct for such a form of boiler, or that they were never intended to apply to such a type of construction.

To explain how the forces would act let us consider first a cylindrical shell subject to pressure. The shell is in complete equilibrium, there is no tendency to change form, and the stress in the metal is wholly along a tangent line. In particular note that there is no tendency of the plate at any point to move outward away from the center. Suppose now a brace put in right across from side to side along a diameter. Such a brace, it is clear, will do no good whatever. The plate does not tend to move in the direction of the brace, there is no stress upon it, and it is entirely without influence for either good or bad.

Now consider the condition of a brace tying together two flat plates, as, for example, the two heads of a boiler. Such a flat plate is not in equilibrium under pressure. Each head tends to bulge outward, and this tendency gives rise to a load on the brace, coming, so to speak, from each end of the boiler. That is, the head on the right, let us say, tends to bulge outward and thus to stretch the brace, and thus throws it into a condition of tensile stress. Similarly the head on the left tends to bulge outward and thus tends to stretch the brace to the left, and so puts a load on it also in tension. These two tendencies balance each other, thus putting the brace into tension and leaving the heads to depend on its strength for their support. If of sufficient strength for the load, the brace holds and the plates are supported.

Now turn to the braces tying the flat crown sheet to the shell of the boiler. Note that the tops of these braces are attached to the cylindrical shell, and that so long as it retains this form there is no load whatever put on the braces by the shell itself. On the lower end the case is different. The plate is flat and tends to bulge downward. This puts a load on the braces and puts them into tension. Now note that to resist this tendency of the braces to come down there is available no pull upward coming from the pressure on the shell. There is available nothing but the strength of the cylindrical shell as an arch. If it is stiff and strong enough as an arch to carry the load without yielding, well and good. This is frequently the case where the flat top of a combustion chamber or of a furnace or fire-box is safely supported in this manner. If not, then it yields and comes down, naturally carrying the sides outward, as shown in the figure. This will continue until the curvature of the shell at the upper end of the braces and that of the furnace crown sheet at the lower end are such as to bring their loads into some kind of equilibrium. That is, after the distortion the shell is no longer cylindrical, and the pressure will of itself tend to force the upper part of the shell back to its original position. This puts a tension upon the braces. Similarly on the crown sheet the curvature is quite gentle and simply relieves slightly the downward load on the braces, leaving still a pronounced tension downward to balance the tension upward coming from the shell. Thus the shell and crown sheet have brought themselves into equilibrium, and aside from the breaking of the rivets at the seams, the boiler might have lived to a good old age and have done good service without further trouble. In any event, as a structure it was in a far more stable and satisfactory condition after the distortion than before, so far as its equilibrium under the internal forces is concerned. The moral of this experiment seems to be: Don't build boilers in this way, or if you do, run circumferential Tee or angle irons around the upper part of the shell. This will strengthen it as an arch, and enable it to support the load coming from the crown sheet.

Q.—Will you kindly explain at length the examples in the educational series on page 47 of the December, 1898, issue, as follows:

$$3\ [16 - 2\ (3 + 4 - 2)] = 18$$
$$3\ [16 - 2\ (3 + 4) - 2 + 4\ (3 - 1)] = 24$$
$$3\ [16 - 2\ (3 + 4 - 2) + 4\ (3 - 1)] = 26$$

I cannot work out any of these to read correctly. The use of [( )] puzzles me completely. STUDENT.

A.—The key to all operations with brackets is to remember that everything within any one pair of brackets is to be considered as a single quantity, and each term within the bracket must be treated in exactly the same manner. The principles are stated and explained in § 8 of the "Calculations for Marine Engineers," to which you refer. You will perhaps understand the examples better by taking the operations more in detail as follows:

The first in § 8 is $2\ (3 + 4 - 2) = 10$. Here we first combine the quantities inside the () and find $3 + 4 - 2 = 5$. This result we then multiply by 2, which gives $2 \times 5 = 10$, the answer.

To reduce the more complicated expressions, such as those which you quote above, a very good way for the beginner is to write the example over again several times, taking off one set of brackets at a time, and thus gradually reducing it to its final value. Thus taking the first one above, we may write it four times over, thus:

3 [16 — 2 (3 + 4 — 2)]
3 [16 — 2 × 5]
3 [16 — 10]
or, 3 × 6 = 18.

Taking the next example, we may reduce it as follows:

3 [16 — 2 (3 + 4) — 2 + 4 (3 — 1)]
3 [16 — 2 × 7 — 2 + 4 × 2]
3 [16 — 14 — 2 + 8]
3 [24 — 16]
3 × 8 = 24

In the last example which you quote there was, by oversight, an error in the location of the last]. It should not include the expression 4 (3 — 1). The example should then read

3 [16 — 2 (3 + 4 — 2)] + 4 (3 — 1),

and we reduce it thus:

3 [16 — 2 × 5] + 4 × 2
3 [16 — 10] + 8
3 × 6 + 8
18 + 8 = 26

By working in this way you will probably have no further trouble with examples of this nature.

Q.—In the February issue, under the head of "Mechanics," in the educational series, there is a rule for finding the H. P. of an engine from the foot pounds work it does. I don't know how to find the foot pounds work of an engine. Will you please give me some rule to find them, for both stationary and marine engines? J. A. B.

A.—The rule you refer to was not intended especially for finding the horse power of an engine, but rather to illustrate the difference between *power* and *work*. The measure of the work in foot pounds per minute for an engine is, however, readily found as follows: By the definiton of work in the paragraph preceding the one to which you refer, the foot pounds for the steam engine will be the product of the acting force multiplied by the distance through which it acts in one minute. The acting force equals the mean load on the piston, and this equals the mean effective pressure per square inch multiplied by the area in inches. The distance moved per minute equals twice the stroke in feet multiplied by the revolutions per minute.

Let p = mean effective pressure in pounds per square inch; A = area of piston in square inches; L = length of stroke in feet; N = revolutions per minute. Then $p\,A$ = acting force or mean total load on piston, and $2\,L\,N$ = distance moved per minute = piston speed.

Hence foot pounds of work per minute equals the product $(p\,A) \times (2\,L\,N)$, or what is the same thing, $2\,p\,L\,A\,N$. Hence

$$H.\,P. = \frac{2\,p\,L\,A\,N}{33{,}000}.$$

This is the usual formula for finding the indicated horse power, and is referred to in § 8 of the "Calculations for Marine Engineers," published in the January number of MARINE ENGINEERING, page 34.

The mean effective pressure p must, of course, be found by means of an indicator card. The details of this operation would, however, take us beyond the limits of the present answer.

For illustration suppose:

p = 32 lb.
L = 3 ft.
A = 2,000 sq. in.
N = 100.

Then mean piston load = 32 × 2,000 = 64,000 lb. Distance traveled per minute = 2 × 3 × 100 = 600 ft. Foot pounds per minute = 600 × 64,000 = 38,400,000. We should find the same result, of course, by multiplying together the five factors, 2 × 32 × 3 × 2,000 × 100. Hence,

$$I.\,H.\,P. = \frac{38{,}400{,}000}{33{,}000} = 1{,}164.$$

Q.—The following is a description of a steam yacht and its engine which I use in New England waters during the summer months. I want to get all available speed out of her, and think a change in the size or shape of the propeller would be to that end.

The yacht is 52 ft. long over all; about 45 ft. water line, and 42 ft. keel; beam on deck 9 1-2 ft., and about 7 1-2 ft. at water line. From this you see there is but little bilge. I carry about one ton of lead on her keel to make her steady, and it answers the purpose first rate. She is very sharp at the bow. The engine is a compound; the H. P. cylinder is 5 1-2 by 9 in., the L. P. 9 in. by 9 in. The boiler is 52 in. high, 42 in. dia. Am allowed to carry 200 lb. pressure. Generally run her at about 160 lb., with 230 revolutions to the minute. Think the engine makes about 1,000 revolutions to the statute mile, but am not certain of this point. The present propeller is 42 in. dia., with about 5 ft. pitch, has four blades and is made of iron. There is room for a 44 in. wheel.

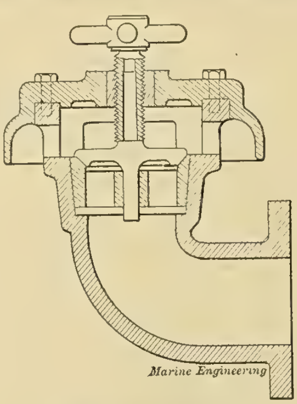
What material would you advise to make the wheel of? Think the galvanization induced by the bronze while under the water rots the iron and makes a blade liable to be broken off in case of striking a log or any partly submerged debris. J. C.

A.—The information given in your statement is not sufficiently complete to make possible a satisfactory determination of the wheel best suited to your purposes. In connection with the boat the draught is not given, and only a rough estimate at best can be made of the displacement. In connection with the engine it is not stated whether it is condensing or non-condensing, and without indicator cards only a rough estimate, at best, can be made of the power developed. If your present wheel is of 5 ft. pitch, then with a probable apparent slip of 15 per cent to 20 per cent the revolutions per mile would be some 1,200 to 1,300 rather than 1,000, or if the latter figure is correct, then the pitch is probably some 6 ft. or more rather than 5 ft. From a general estimate of the conditions, it seems likely that you would do rather better with a wheel of smaller diameter, smaller pitch ratio, and higher revolutions, say 36 in. dia. and 45 in. pitch, running from 300 to 350 revolutions per minute. If, however, it is desired to keep the revolutions at about the present number, then the dimensions given are probably not far wrong, provided, of course, that the blades are of suitable area, shape and thickness.

For material, manganese bronze is probably the best, and next common brass. With either of these materials the wheel may be made with smoother surfaces, thinner sections and sharper edges than with cast iron, all of which will help in reaching a higher speed.

Q.—Please explain what a "snifting valve" or "snifter" is and for what it is used. H. H. A.

A.—The snifting valve was a valve fitted to the older types of jet condenser. In form it was a disk valve, carried on a spindle, as shown in the figure, opening outward, and provided with a hand wheel and screw for holding it down when desired.



SNIFTING VALVE.

To this extent it was similar to a boiler feed-check, opening outward instead of inward. Means were provided so that when making preparations for getting under way steam was blown directly through into the condenser, thus driving the air out through the snifting valve. When the air was thus expelled and the condenser filled with steam the injection was turned on, thus forming a vacuum. The snifting valve would then automatically close, preventing the return of the air, and for extra precaution could be kept closed by the screw hand wheel if desired.

RECENT PUBLICATIONS.

The Old Navy and the New. Memoirs of Rear-Admiral Daniel Ammen, U. S. N. (deceased). J. B. Lippincott Co., Philadelphia, Pa. Second edition. Size, 6 by 9. Pages, 553. With frontispiece. Cloth, $3.25.

During and since the war naval matters have held a very prominent place in the attention of Americans. Scores of publications, of one sort or another, descriptive of the Navy have been issued and found wide-spread sale. In most instances, however, these have described the Navy as it is, and a knowledge of the present has induced in the minds of readers a desire to know of the past. For such, much of interest is to be found in the memoirs of the late Rear-Admiral Daniel Ammen, U. S. N., now issued in a second edition under the title of "The Old Navy and the New." The book is many-sided, possessing the interest of personal narrative of a traveler; the historical value of a link connecting the days of sail power with the era of forced draft and 20-knot ships; an insight into social life in the Navy; and so on, giving special information for the specialist and a pleasing combination and variety for the general reader. Admiral Ammen had to his credit a record of more than half a century ashore and afloat. His birthplace was in Brown county, Ohio, and here he first made the acquaintance of a boy whom he one day saved from drowning, and who years afterward was known to the world as President U. S. Grant. It is curious to read of the author's trip to Washington after his appointment in the year 1836, in a stage coach, wrapped up in a Mackinaw blanket, in the company of a lot of Congressmen, trying to keep warm in similar style with the aid of generous draughts of whiskey at the roadside taverns. To-day a Pullman car at forty miles an hour, and dinner on the way, would be the usual way of travel. In the course of his service Admiral Ammen saw a good deal of this earth, both the dry land and the deep waters, and as he was observant and possessed of a sense of humor he, in the course of fifty years, got lots of material for a 500-page book. He also seems to have had a mechanical bent which, in later years, found expression in the armored ram Katahdin. Early in his career, when in a vessel which touched at the island of Java, he noted the primitive method of pile driving. The weight was suspended by a single rope, which at the free end was spliced to twenty separate ropes, each of which was held by a Malay. By alternately hauling and letting go they obtained a fall of about three feet for the weight. An incident which the author narrates at some length recalls the recent osculatory performances of Naval Constructor Hobson. When the U. S. S. St. Lawrence was lying of Southampton, Lieutenant "B," with some brother officers, attended a town ball, and the author says:

"'B' was always jovial, and being in a window recess with one of the ladies, took the liberty of kissing her. He said that she would not have objected at all had not the curtain allowed the act to be seen by the company." The matter was reported to the captain, and the lieutenant was tried by court martial. He pleaded guilty, but in his defense referred to an order issued during the reign of George II, to the effect that "His Majesty's sea officers are strictly enjoined to be polite to the ladies." Though this order was not mandatory on other than British officers it was the lieutenant's desire to carry out the order on British soil. "As the woman was 'full grown, and had not suffered bodily injury, 'B' was admonished."

The difficulties of navigation in vessels with both steam and sail power are referred to in the narrative of an experience in the Pacific. "I was surprised to see how helpless side-wheel steamers were when under sail alone. The wheels were lashed, the upper paddles taken off, and then the wheels turned over so as to get rid of the drag of the paddles." In these days of long, continuous fast steaming such a proceeding would certainly be novel. The Admiral seems rather to have mistrusted the skill of engineers in general, and he cites a few instances in the book which show that probably his opinions were not formed without cause. He was ordered to join the U. S. S. Water-witch on a survey expedition to the South American coast. This vessel was of 378 tons and was fitted with feathering paddle wheels "very much too heavy for her." Of his experiences he writes:

"A voyage of five days brought us to Maranham. A considerable indentation in the coast after reaching the wide mouth of the river Amazon enabled us to escape the current until we were near our port, and also the force of the trade winds. The shoal grounds near the outer limits of the Amazon are ooze, so soft that a lead in sounding sinks several feet in it; in consequence we found ourselves held back, the revolutions of the paddles being greatly retarded by the ooze through which the body of the vessel was passing in part. On heading more to seaward we soon got into deeper water, and our paddles made their usual number of revolutions. The engineer in charge was a mere youth, and inert withal. The great weight of the wheels perhaps caused the shaft-bearings on the vessel's side to settle. We should have attempted to line them at Georgetown had it not been for the prevalence of the fever; the operation was on that account deferred until we should reach Maranham. It was intended that this should be done while we were engaged in coaling. As a result of laziness and ignorance, we had not made our inefficient preparations when we had finished coaling. It was supposed that a little pair of jack-screws with a plank between them as a bearing under the shaft, placed on the deck just as near the ship's side as possible, aided by a little screw placed on the end of a rod on the outer part of the wheel, and secured to the masthead, would suffice. From the lack of leverage the idea was ridiculous; and after wasting several days, and having a man knocked overboard from the wheel house by something giving way, his arm being broken at the same time, I suggested to the engineer a simple and obviously effective means of raisng the shafts; although he assented, he was still unwilling to ask the captain to adopt the means proposed. There were a number of lighters of twenty tons' displacement anchored near us; the proposition was by means of cleats to secure stout timbers on the vessel's sides, then lash and wedge these under the wheels after the lighters had been filled with water; when the lighters were baled out they would of course raise the weight of the wheels, which was not one-half of the weight they would float. This was finally done at my suggestion and under my personal superintendence, notwithstanding one of the younger engineers screwed down a pillow block to prevent the shaft from rising. On bailing out the water, as soon as the timbers upon which the wheel was resting began to crack I knew that some rascality was being practised to prevent the operation, and on reaching the deck I saw what it was. We were a fortnight in Maranham, having been detained more than a week through incapacity. At times I have doubted whether the shafts really needed lining; but, at any rate, they were raised half an inch or more at the bearings on the side of the vessel."

With a touch of humor the author relates another "engineering" experience when in command of the U. S. S. Piscataqua. She was put in commission late in 1867 as flagship on the Asiatic station. She was ship rigged and had also a screw propeller, with a disconnecting coupling in the line shafting, with the intention that sail alone would be used in favorable weather. The coupling was placed about 100 ft. from the stern, so that when free the screw had to turn this length of shaft.

"On taking command," says the author, "I had said to the engineer, 'It seems to me that this will be a great retardation.' 'Very little,' replied my scientific friend; 'when the vessel has headway the shaft will turn, and after the revolutions commence it will turn almost without friction.' I found the reverse to be the case, however, and thought of what the blocks said of the boatswain when they creaked. At a time when there were no friction rollers in blocks, if the latter were not carefully oiled there was great friction, and when they made a noise the sailors would say they were 'damning the boatswain.' So when at sea the vessel made a frightful thumping in turning over 100 feet of the shaft, and I saw that she made only seven knots when otherwise she would have made ten, I could not help thinking that the thumps were damning the engineer who had made it necessary to turn a large part of the shaft that could have been kept quiescent by uncoupling it as far aft as possible."

Civil war experiences fill many interesting pages. Many of his recollections of this time are side lights on now historic events of the war. At the commencement of the war the writer was in Baltimore, and being unable to get northward he secured a horse and rode to Washington, where he offered his services to Commodore Stringham, then in charge of the office of detail. Having no further use for a horse he sold the beast to the patriotic Colonel Ellsworth, who five days afterward was killed at the Marshall House in Alexandria. In 1863 Admiral (then Commander) Ammen formed one of a board to report upon the qualities of the monitors and to make suggestions for their improvement. The board made a number of recommendations and criticisms which referred to lack of ventilation, leakage of water under the turret, disablement of the turret by impact of shot, inadequate armor, and many minor changes in construction and equipment. "In relation to the qualities of the vessels," says the report, "we would remark that they have been exaggerated into vessels capable of keeping the seas and making long voyages alone. . . . When employed against vessels of any class known to us, in smooth harbors, they will hardly fail to be in the highest degree effective, and when their bottoms are clean, would prove powerful rams against vessels of low velocity, or against vessels of greater velocity when embarrassed in intricate or narrow channels." Later in his memoirs he refers to the famous ocean voyage of the monitor Miantonomah with the true comment: "Her voyage furnished an incentive to the European powers to compete in the construction of armored ships, which has continued to the present time, to the end that the last one built should be in point of size, armor plating and battery, more formidable than any that had preceded her." Throughout the book there are frequent references to the author's friendship with General Grant, and in the form of an appendix letters written by General Grant during his trip around the world are preserved. There is a frontispiece of the Admiral, and illustrations of the U. S. S. Katahdin. Other than these there are no illustrations in the volume, but it does not depend for its interest on pictorial display, and then during many of his years of service photography was unknown. The volume is handsomely bound in blue cloth, and is published by the J. B. Lippincott Co., of Philadelphia, Pa.

The British Navy. By A. Stenzel, Captain Imperial German Navy, retired. Translated by A. Sonnenschein. New York, E. P. Dutton & Co. With maps, colored plates and engravings. Size, 7 by 10. Pages, 327. Cloth, $5.00.

For those interested in the subject this is the most satisfactory book that we know of. The author has undertaken his work in a reverent spirit, with a full realization of the grandeur of the subject, and this spirit has been carried out by the translator, who has faithfully followed the original text, changing no statement, but adding only a word by way of commentory here and there, in foot notes. It is a book far above the average of such works, for though written in an easy and good literary style, free from obscure technicalities, it is manifestly the appeal of a graduate in naval affairs to the understanding of a highly intelligent audience. After reading the book one is amazed that any one not a Briton could have gathered together such a multitude of facts about so complicated a subject, and one so intimately connected with that nation's life. In this fact there is the peculiar merit that the work is so impartial and dispassionate, without a trace of exaggeration which a patriotic British writer might be expected to show. The work is divided into these subdivisions: Historic Survey; Admiralty; Naval Policy; Stations, Dock Yards, etc.; Personnel; Education and Training; Uniform; Flags; Service and Discipline on Board; Material, and Conclusion, containing a detailed classification of British vessels. The subject is, of course, tremendously big, and this has demanded nice discrimination, so as to apportion the space at the disposal of the author that each division shall have a proper proportion and relation to the others. He has been very successful in this, by the skilful use of condensation rather than omission, and he has also freed himself from the hypercritical condition of mind which an officer of a continental power might, even unconsciously, assume. In the work of translation Mr. Sonnenschein has availed himself of the professional aid of F. W. Crohn, of Yarrow & Co., Poplar, and of F. Harrison Smith, R. N., so that great accuracy has resulted in the correct rendering of technical terms, especially for those which have no exact equivalents in English. In his preface the translator has called attention to these details and has added as an illustration the distinction, familiar to German readers, between the terms officer (Offizier) and official (Beamte). In view of recent occurrences in the Philippines the significance of these terms is of great present interest to American readers. "Official (Beamte)," says the translator, "denotes the medical officers, paymasters, etc.; in a word, non-combatants, who are not called by the name of officer in German. Indeed, there is an important difference in the German navy between the two classes. The 'officers,' like the crews, take the oath of allegiance to the emperor solely, the 'officials' are sworn to the imperial constitution as well as to the emperor." In the book there are thirty full plate illustrations, twenty-five engravings, and thirty diagrams printed in the text, and four folded maps and plans. Though it is an invaluable book of reference it is no dry recital of regulations and statistics. There are many odd bits of information and comment throughout the book. One of these, for instance, refers to the term "Jack Tar," which is very generally supposed to have originated from the use of tar on the old wooden ships. The author, however, attributes its origin to the use of tarred garments (tarpaulin) by sailors, which "suggested the good-natured nickname 'Jack Tar,' equivalent to 'Blue Jackets.'" Another fact concerning uniforms, which would be a surprise to many, is that the present style of dress of British sailors was adopted only as late as 1857. Previous to that there was great diversity in dress according to the taste of the commander. "As late as 1853 the commanding officer of H. M. S. Harlequin ordered his gig's men to be dressed as harlequins." This book would make a most valuable addition to any marine library, and among its special uses would be that of a handbook of reference for a yachtsman who intended to cruise in foreign—especially British—waters. The colored plates showing distinctions of dress, etc., would for this purpose be a great convenience.

"Centrifugal Pumps, Turbines and Water Motors," by Charles H. Innes, M. A., of Rutherford College, Newcastle-on-Tyne, England, has appeared in a second edition with additions. The subject is very appropriate for a book coming from the author's place of residence, which has long been identified with hydraulic work in its modern engineering forms, for here are the Armstrong works. The book is of convenient desk size for ready reference, and contains over 200 pages, with many drawings and graphic solutions. It is divided into seven parts, which cover:

General principles; pressure engines, producing rotary motion; turbines, where power is obtained by altering the direction of motion and the velocity of the water; steam turbine of the Parsons type; agreement of theory with experiment in water turbines; the centrifugal pump; the fan, and a description of the hydraulic work at Niagara Falls, concluding with a description of the hydraulic buffer stop. The book is scientific rather than descriptive, treating of the mathematics of the subject, and is written especially for the use of engineering students who have the necessary mental equipment to get results out of the book. The book is published by The Technical Publishing Co., Manchester, England, price 3s. 6d., and is for sale here by D. Van Nostrand Co., 23 Murray street, New York.

We are in receipt of the "American Trade Index," more extensively described as a "Descriptive and Classified Membership Directory of the National Association of Manufacturers of the United States," arranged for the convenience of foreign buyers. It is issued from the main office of the association in The Bourse, Philadelphia, Pa. The book consists of 124 pages of text, giving in alphabetical order the names of firms "who make goods suitable for export;" also their addresses and a description of their output and a list of their foreign correspondents. Then follow 134 pages containing a "Classified List of Members," grouped according to the articles which they produce. This book is one of a class of publications which are good enough as far as they go, but unfortunately their contents are influenced by circumstances which prevent their being wholly impartial. In the first lines of the preface the reader is informed that it is the purpose of the "Index" to furnish merchants interested in American goods a *comprehensive* handbook of *the* leading manufactures of the United States, though this statement is modified by inference further along. It would have been wiser to have come out flat-footed and said the purpose of the book was to furnish merchants with a classified membership of the association. For example, under the head of "Shipbuilders" no mention is made of any yard west of Chicago, so that an Oriental reader, who was in the market for ships, might readily believe he could only order from the Atlantic coast. No index which omits the names of the Pacific coast builders—remember the Oregon—could be properly styled *comprehensive*. However, seeing that the book is distributed gratis to merchants without the United States, there is not much room for the reader to complain.

Our New York contemporary, the *American Shipbuilder*, has come out in a new dress of type and attractive make-up. Its paragraphs of "New York Marine News" are a feature of the paper and are very interesting, and as publication is made weekly they are up to date. The proprietors, Bradley & Howell, are now making a specialty of marine photographs for sale.

On the anniversary of the blowing up of the U. S. S. Maine in Havana harbor, February 15, the keel of the new battleship Maine was laid at Cramp's Shipyard in Philadelphia, Pa.

A deal is reported from San Francisco by which the Santa Fe R.R. Co. and the North German Lloyd S.S. Co. will co-operate in establishing a line of steamships from there to ports in the Far East when the extension of the Santa Fe road to San Francisco shall have been completed.

Wrecking operations on the Spanish cruiser Reina Mercedes, begun since the close of the war, have been so far successful that it is probable that this vessel will be able to sail for the United States under her own steam. It will be remembered that she was sunk by the Spaniards with a view to blocking the entrance to the harbor at Santiago.

TRADE PUBLICATIONS.

Two folders are at hand from the Roe Stephens Mfg. Co., Detroit, Mich. One is devoted to check, globe and angle valves, the other to throttle valves. Each folder contains several illustrations, and the several valves are fully described.

"The latest and best thing in patent sheaves, being the successful application of the ball-bearing principle," is the brief statement which will attract attention on handy desk blotters sent to all who wish them by Wilcox, Crittenden & Co., Middletown, Conn.

"A New Engine Motion" is the title to a catalogue neatly printed in two colors and ready for distribution by the Parsons Engine Co., Wilmington, Del. The engine is of the reciprocating type, but has peculiar characteristics of its own. The whole device is thoroughly illustrated.

"Graphite" is the title to a four-page publication sent gratis to all inquirers by the Joseph Dixon Crucible Co., Jersey City, N. J. The object of the publication is not to boom any special business, but to attract attention to the many uses for graphite, for lubrication, paint and other purposes.

"Learn to Draw" is the title to an eight-page circular issued by the International Correspondence Schools, P. O. Box 1111, Scranton, Pa. It describes in much detail the school of drawing in connection with this institution, and includes all lines of mechanical drawing such as marine engineers would be interested in.

The McClure oil pump for cylinder lubrication is illustrated and described in a catalogue issued by the McClure Oil Pump Co., Detroit, Mich. It is the invention of an engineer of years of experience on the Great Lakes and will interest all of our readers. The catalogue is pocket size and gives quite a complete description of this pump.

A finely illustrated catalogue bound in heavy red paper and printed in gilt is received from Loring Coes & Co., Worcester, Mass., giving much valuable information regarding the machine knives and the pyrocalcic hardening process of this company. The catalogue is very fully illustrated, several pages being devoted to a department of custom hardening.

Multipolar dynamos and motors are handsomely illustrated and completely described with sectional views, special attachments, etc., in a 32-page bulletin issued by the C & C Electric Co., 143 Liberty street, New York. Accompanying the illustrations are many tables, and there is much other descriptive matter, making the bulletin of much value to anybody interested.

Packings manufactured by the Boston Belting Co., 256 Devonshire street, Boston, Mass., are thoroughly told about and depicted in a 36-page pocket-size catalogue just received. It is printed in two colors on an excellent quality of paper, making the catalogue attractive, and as the subjects include packings, valves, gaskets and diaphragms, all of our readers will want to send for a copy.

"The Westinghouse Standard Engine" is the title to a superb specimen of the printer's art issued by the Westinghouse Machine Co., Pittsburg, Pa. The paper is heavy and coated, and the cover is rich green printed in silver and black. The catalogue contains fifty-four pages, giving a most complete detailed description of the several types of these engines. These include very fine sectional views illustrating thoroughly the construction of the engines, and the several parts are fully illustrated, making the catalogue very complete. These engines are especially adapted to compact electric sets. Copies can be had on application.

Fairbanks-Morse Gas Engine Co., Chicago, Ill., has issued a very handsomely-printed catalogue devoted to a description of the engine and the many uses to which it is applied. It is of the stationary type, and one of the applications is of particular interest to our readers, as it refers to an air-compressor direct-connected to an engine for use in shipyards and other places where portable power is desirable.

A pocket memorandum book is sent gratis by the Sprague Electric Co., 20 Broad street, New York, to all of our readers who mention Marine Engineering. It contains calendars for the present year, also for 1900, and much valuable information regarding dynamos, motors and other electrical subjects, with holidays, weather reports, postage rates, tables of horse power, together with many pages in diary form.

The compartment system on ships is useless without effective water-tight doors. A little pamphlet regarding this subject is issued by the "Long Arm" System Co., Garfield Building, Cleveland, O., describing the application of the devices manufactured by this company, which are not untried, as the cruiser Chicago is fitted with a system of eleven doors. This little pamphlet describes in detail the operation of this system and its many uses.

The sectional water-tube boiler manufactured by the Almy Water Tube Boiler Co., Providence, R. I., is very thoroughly described and completely illustrated in a catalogue just issued. The illustrations are wood cuts of large size which show sectional views of different types and shapes of this boiler. It is a complete catalogue, and is one that should be in the hands of every user of boilers. A list of boilers supplied in the past eight years includes the names of some of the most prominent yachts and smaller size steamboats in all parts of the country.

"For Your Good and (incidentally) Our Own" is the title of a pocket-size pamphlet issued by the Montauk Multiphase Cable Co., 100 Broadway, New York. It is neatly bound with paper cover and is printed on a delicate tint of green paper in two tints of green ink. The construction of this cable is told in considerable detail and the many uses to which it is adapted for fire-alarm purposes either on board ship or in a building. It is intended to take the place of a watchman, and the cable is so constructed as to be capable of "discovering dangerous heat or incipient fire from every infinitesimal point of its length and giving warning thereof, locally and centrally," as the text states.

The January issue of the handsomely-printed and valuable set of bulletins issued by the B. F. Sturtevant Co., Jamaica Plain, Mass., is devoted to the Sturtevant eight-pole motors and generators, direct-current. This machine is shown direct-connected to an automatic single upright engine, the motors to electric fans, of which there are two illustrations, one being a special type of suspended fan designed especially by this company for ventilating vessels. Bulletin G regarding the Sturtevant generating sets was in such demand that a second edition was printed, and those of our readers who were not able to secure a copy of the former edition can now be supplied. This bulletin contains illustrations and full descriptions of eight sets, different sizes and styles. Copies of either of these bulletins can be had by applying to the company at Jamaica Plain, Mass.

Calendars Received.

From the Joseph Dixon Crucible Co., Jersey City, N. J., with a very effective lithograph in colors of a young woman in cap and gown holding a rose to an owl.

From the Ashton Valve Co., 271 Franklin street, Boston, Mass., a strong engraving of two children, "chips of the old block," one playing with a toy locomotive and the other with a toy steamboat.

Copies can probably be had from the companies by writing for them.

BUSINESS NOTES.

Blue-Printing Outfit.—Draughtsmen and others who do any blue-printing will be interested in the special appliances advertised elsewhere by the F. W. Emerson Mfg. Co., Rochester, N. Y.

Marine Sash Balances.—A line of sash balances designed especially for yachts and vessels of any size is offered by the Pullman Sash Balance Co., Rochester, N. Y., whose advertisement is elsewhere in this issue.

Fine Tools.—Every user of fine tools appreciates the value of quality as well as a special adaptability to the use for which they are wanted. Among the concerns making a specialty of such tools is the L. S. Starrett Co., Athol, Mass.

A Lathe for Repair Shop.—Nearly every steam vessel of any size needs a repair shop of greater or less capacity, and a lathe designed especially for these uses is offered by the Seneca Falls Mfg. Co., Seneca Falls, N. Y.

Tube Expanders.—Users of tube expanders will be interested in the advertisement of A. L. Henderer's Sons, as this company makes a specialty of this kind of tool. Full information regarding the various types can be had from the company at Wilmington, Del.

Portable Fire Extinguishers.—Every yacht and vessel requires fire-extinguishing apparatus, and among the portable ones is the "Stempel," which is sold by H. R. Bennett, 1217 Filbert street, Philadelphia, Pa. Full information regarding these extinguishers and their use is sent upon application.

Hollow Staybolts.—The high quality and strength of hollow staybolt iron has led to the extensive use of the staybolts manufactured by the Falls Hollow Staybolt Co., Cuyahoga Falls, O., by marine boiler builders, locomotive manufacturers, etc. One of the recent orders of this company is for half a car load for the Pacific coast.

Yacht Lighting Sets.—The Bullock Electric Mfg. Co., Cincinnati, O., reports having received orders for six electrical equipments for yachts in one day recently. The machines used to fill these orders were in size 7 1-2 or 10 K. W. Readers interested in the subject of electricity can secure full informaton from the Bullock Company.

Electricity at Sparrows Point.—In the renovation of the shipyard of the Maryland Steel Co., at Sparrows Point, Md., electricity was very generally made use of, and the C & C Electric Co., 143 Liberty street, New York, supplied a considerable amount of apparatus, including two large generators, ten motors of 6 horse power and one motor of 10 horse power.

Pocket Spirit Level Sent Free.—The Duval Metallic Packing Co., 126 Liberty street, New York, is giving out a most practical souvenir in the shape of a pocket spirit level. It is made of hard rubber, octagonal in shape, being about 4 in. long and little larger in size than a lead pencil. The advertisement is read through the bubble in the glass. These very unique souvenirs may be had upon application.

A Busy Shipyard.—The Morse Iron Works has at present several large contracts on hand, some of which are of particular interest. Among them is the U. S. transport Panama now being fitted for cable-laying service among the Philippine Islands. The S.S. Berlin is being refitted and thoroughly overhauled. Her first trip will convey Secretary Alger and army officers on a trip of inspection to Cuba and Porto Rico. The lake steamer Aragon is being overhauled and fitted with new machinery, and will hereafter float in salt water in the coal service for the Chesapeake & Ohio R.R Co. The steamship Wetherill, which recently had her bow stove in, is being repaired, and the steamer Kanawha is undergoing a general overhauling. The Morse yard is at the foot of 26th street, South Brooklyn.

A Large Order for Tubes.—A large order for tubes for the Mare Island Navy Yard was recently awarded to Merchant & Co., of Philadelphia, Pa.

Valve Reseating Machine.—Almost every engineer will appreciate the value of a valve reseating machine, and will therefore be interested in the advertisement of the Leavitt Machine Co., Orange, Mass., in our advertising pages.

A New Safety Boiler.—A new type of safety boiler is being put on the market by the Mississippi Safety Boiler Co., St. Louis, Mo. The advertisement of this company refers to it briefly, and full details can be had by writing to the company.

Cushions and Upholstery.—The facilities of M. W. Fogg, 18 Fulton street, New York, have been pretty well taxed this winter to keep up with the orders for cushions and upholstery to supply the many new yachts and other steam vessels under construction. This company limits itself to cushions and upholstering work.

Armstrong Tools Sharpened Free.—The Armstrong Manufacturing Company, of Bridgeport, Conn., which manufactures a general line of water, gas and steamfitters' tools, sharpens and repairs all dies and bits of its own manufacture which may be returned to the factory by users of these tools. Of course this does not apply to tools in which the teeth are broken to any extent, as the company does not undertake to insert new teeth; although in some cases dies that lack only one or two teeth can be repaired.

Throttle Valves.—Goldsmith throttle valves are especially adapted for marine engines and large steam pumps (working automatically or otherwise), and the pressure is utilized as the means of packing. The valve opens and closes easily and quickly. The first movement of the lever moves the auxiliary valve, uncovering ports in the main valve, making about an equal pressure above and below the main valve, thereby causing the main valve, in its movements, to act as a balanced valve. A catalogue can be had by addressing the Roe Stephens Mfg. Co., Detroit, Mich., or Scott Valve Co., Chicago.

ZINC WHITE IN MARINE PAINTING.

Within a few years after the discovery of the modern process for making zinc white, the French naval authorities, after severe tests, ordered its use to the exclusion of white lead on the interior of all vessels of the French navy. Experience has confirmed its superiority for painting structures exposed to sea-air and sea-water, and the French navy as well as the French steamship companies now universally employ it, while it is also the official base for painting lighthouses and Government work on the seashore. The French Marine authorities also use it for painting galvanized iron plates, the hulls of torpedo boats, the shells of metal pontoons, etc.

That the French navy should have been earliest to adopt this practice is natural, since zinc white was first generally introduced in France. But the naval authorities of the United States, having made their own experiments with the same results, have adopted zinc white as the fixed component of all paints used either in the Navy or by the Lighthouse Establishment. The famous "White Squadron" obtained its color from zinc white, and remained white because zinc does not change color. Ten tons of American zinc white is the cruising allotment for each ship, and it is used liberally and effectively.

Similar testimony is found in the U. S. Lighthouse specifications, which require, for white, a mixture of one-fourth lead and three-fourths zinc, and for tinted paints, American zinc white and yellow ochre, with no lead. "The colored paints are wanted for outside use and are required to withstand the bleaching effects of salt water and sunlight."

The durability of zinc white is due to its chemical stability and to the large proportion of oil it carries to the painted surface. No other white pigment approaches it in this respect. It is the one white paint material that is capable of resisting salt water and salt air. Added to other materials it shields them and gives them durability.

Advt. NEW JERSEY ZINC CO.

ANNIVERSARY NUMBER—WITH INSET SUPPLEMENT.

MARINE ENGINEERING

Vol. III. NEW YORK, APRIL, 1899. No. 4.

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FOR CLASSIFIED INDEX TO ADVERTISERS SEE PAGES 102, 103 AND 104.

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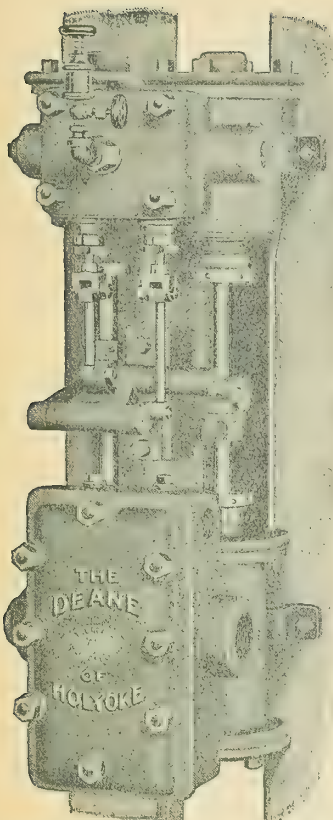

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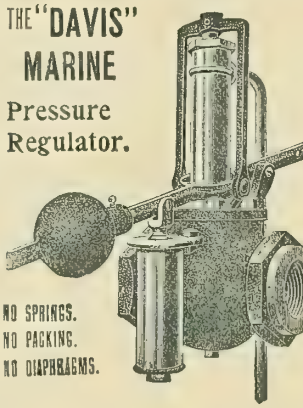

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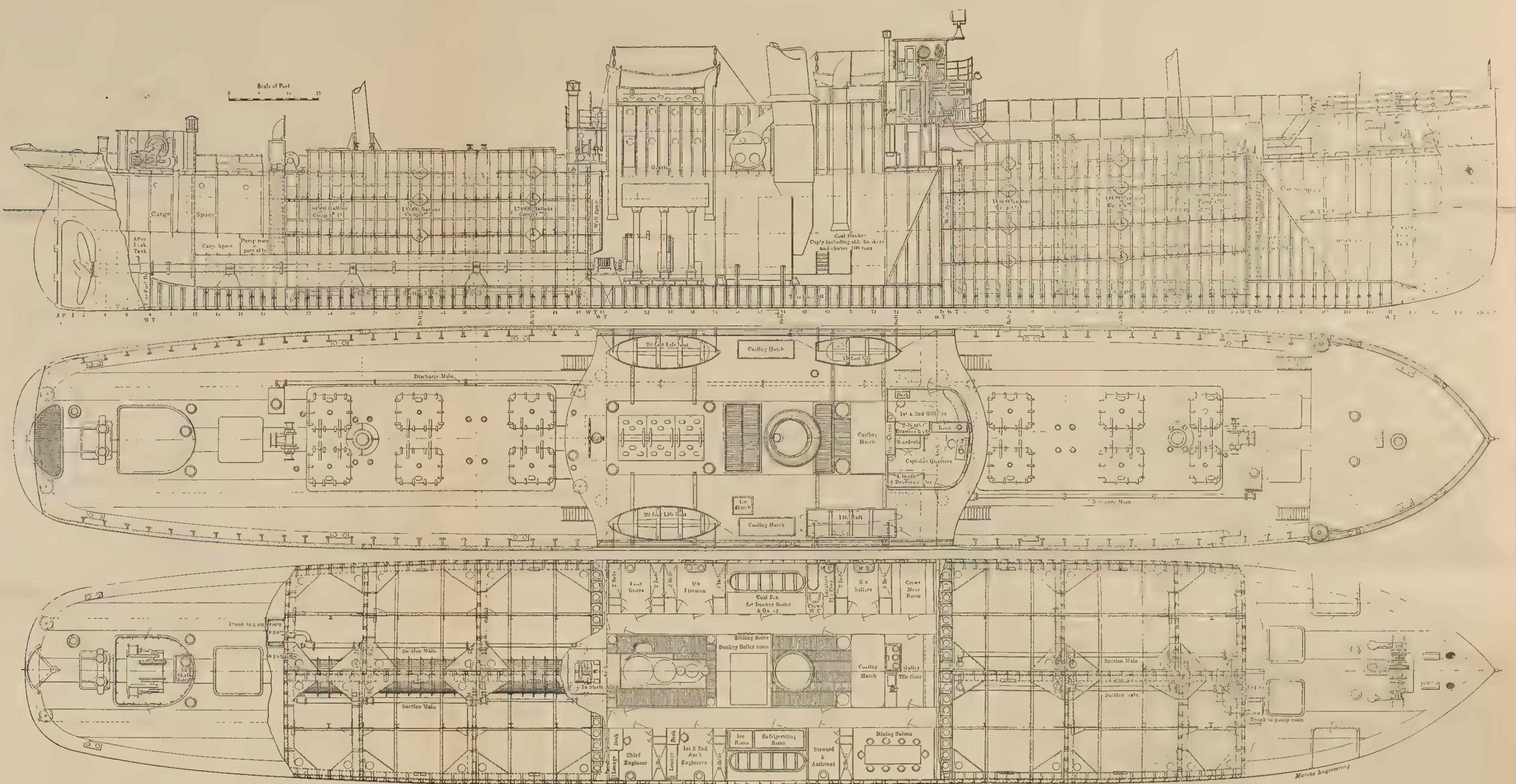
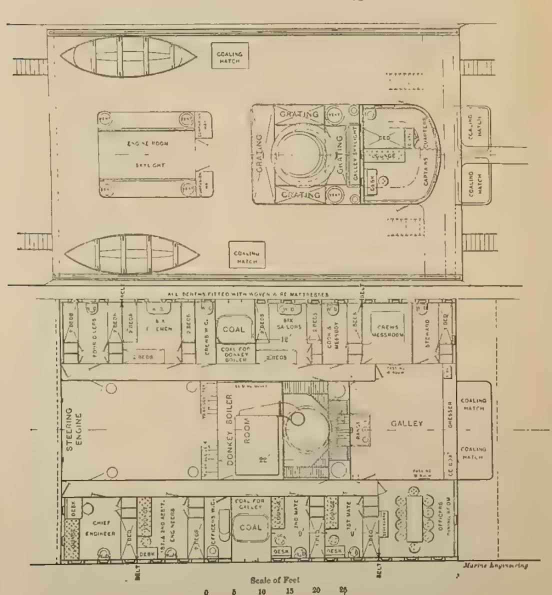
Designed by John Haug, Consulting Engineer, Philadelphia, Pa. Built and Engined by Delaware River Iron Shipbuilding and Engine Works, Chester, Pa.

(Supplement to Marine Engineering April, 1899. See Pages 27, 28, 29 and 30.)

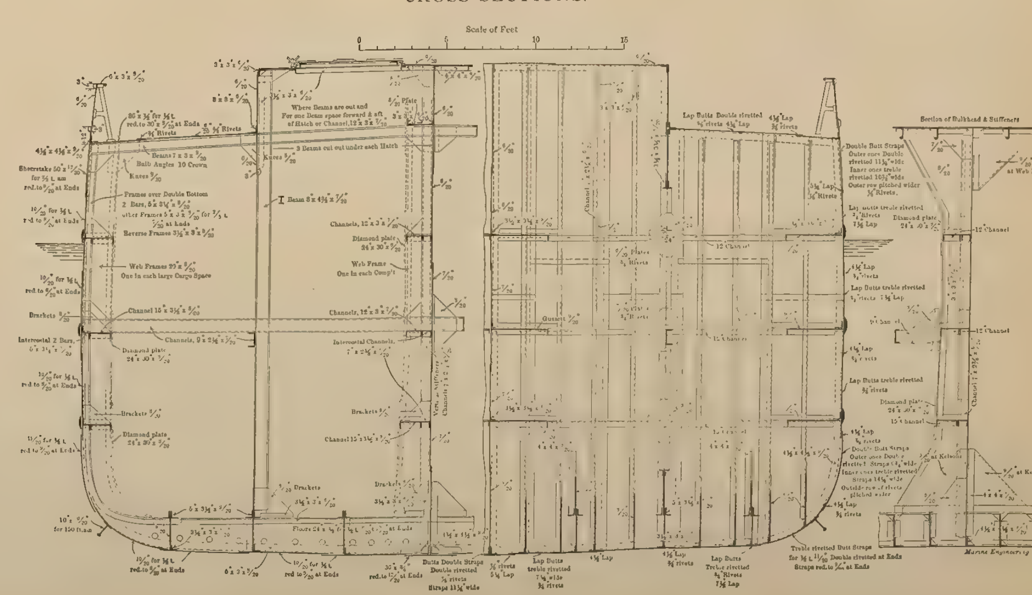
INBOARD PROFILE, DECK AND HOLD PLANS.



ARRANGEMENT OF LIVING QUARTERS.



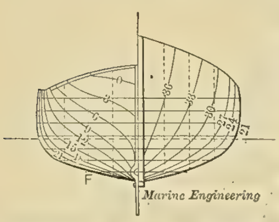
CROSS SECTIONS.



MARINE ENGINEERING.

Vol. 3. NEW YORK, APRIL, 1899. No. 4.

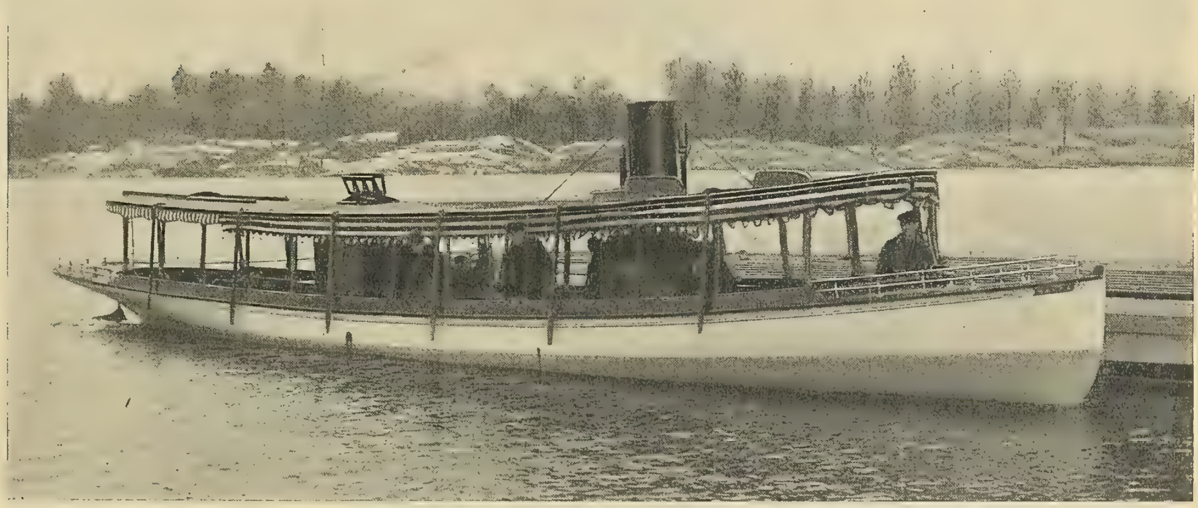
STEAM YACHT WANDA, BUILT BY POLSON IRON WORKS, TORONTO, CANADA.



Our engravings show the very handsome composite steam launch Wanda, built last summer by the Polson Iron Works, of Toronto, Canada, for Timothy Eaton, one of the leading merchants of that city. The dimensions of the vessel are: Length, extreme, 70 ft.; length, water line, 60 ft.; beam, extreme, 8 ft. 3 in.; draught aft, 3 ft. 6 in.; and displacement, 24,000 lb.

The machinery equipment includes a triple-expansion engine, driving a single screw, and having cylinders 5 1-2 in., 8 1-2 in. and 14 in. dia., and 8 in. stroke. The running speed is 400 revolutions per minute. A Mosher water-tube boiler furnishes steam at 200 lb. pressure. This boiler measures: Length, 48 in.; width, 48 in.; height, 56 in. It has 11 ft. 8 in. of grate surface and 400 sq. ft. of heating surface.

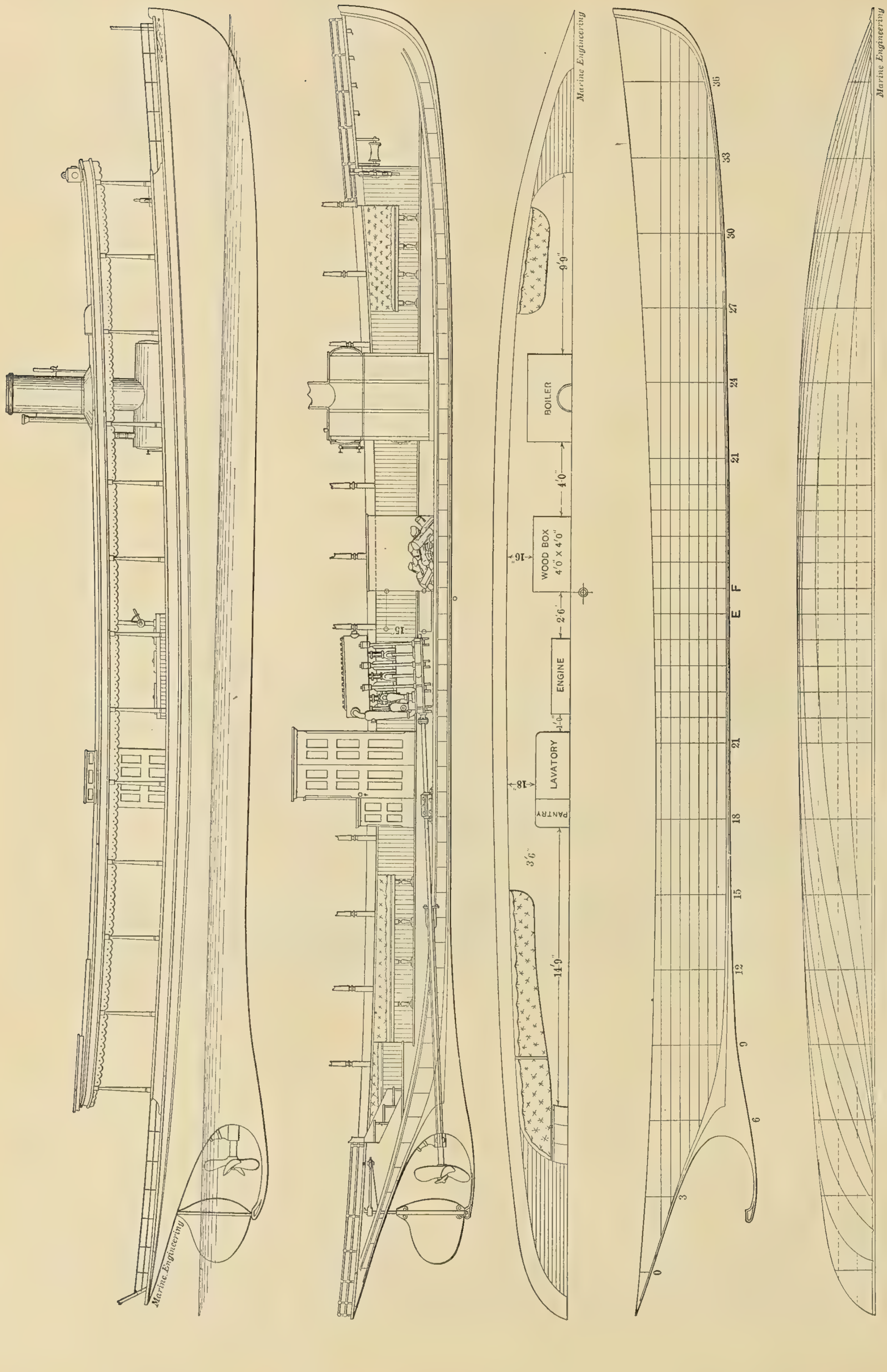
Angle steel 2 1-4 by 1 1-2 by 3-16 in. is used for the frames, which are spaced 16 in. centers, and the same material is used for the keelson and bilge stringers, double back to back, and also for the top height stringer. A plate sheer strake and plate deck stringer completes the use of steel. The whole is planked with clear British Columbia pine 1 3-16 in. thick, fastened with cheese-headed bolts recessed into the planking and plugged. The forecastle and poop decks are of clear white pine. Internal wood work is all of bright cherry and red oak, upholstered in maroon plush, velvet and corduroy, with Wilton carpets. The railings and stanchions are of brass, nickeled, and this makes a very pretty contrast with the bright upholstery and wood work. Shade and storm curtains of striped duck are fitted all around the boat.



CANADIAN STEAM YACHT WANDA ON LAKE MUSKOKA, ONTARIO.

On Lake Muskoka, Ont., the Wanda is used by the owner to connect between the railway wharf at Gravenhurst and his summer residence at Windermere, on the lake, a distance of 25 miles. The vessel was designed to cover this in an hour and a half, and does so regularly, using wood for fuel. When let out she has made the run in an hour and twenty minutes.

The launch was designed by W. E. Redway, N. A., who also superintended its construction.



PLANS AND LINES OF THE S. Y. WANDA, BUILT BY THE POLSON IRON WORKS FOR T. EATON, OF TORONTO, ONTARIO.

PERFORMANCES OF U. S. S. OREGON DURING THE RECENT SPANISH WAR PERIOD.*

BY P. A. E. CHARLES A. E. KING, U. S. N.

MANILA, March 18, 1899.
SECRETARY OF THE NAVY, Washington, D. C.:—
The Oregon and the Iris arrived to-day. The Oregon is in fit condition for any duty.
DEWEY.†

The U. S. S. Oregon, attached to the Pacific Station, was docked at the Naval Station at Puget Sound, State of Washington, on January 4, 1898, and, having had the usual docking repairs made, her bottom cleaned and painted, and all outboard fittings examined and found in good condition, was floated on February 16, 1898.

What proved to be the most remarkable voyage in the history of battleships began at 6:10 A. M., on March 6, 1898, when the main engines, having been tried under steam, were reported ready to the Chief Engineer by P. A. Engineer C. N. Offley, U. S. N., who was the engineer officer on duty at that time. The engines were worked by signals from deck from 6:40 to 6:50 A. M., when the signal was received "Ahead full speed." From that time until 8:30 P. M. on May 24, when the engines were stopped and the Oregon anchored off Jupiter Inlet, Florida, this remarkable machinery, cared for and manipulated by an engineer department whose perfect organization and rare ability stand pre-eminent, worked without a serious casualty.

The history of this voyage, as given in the steam log books, is a story of ceaseless vigil and painstaking care on the part of the engineer personnel. Countless small defects, inseparable from such a run under steam, were detected and at once remedied, and no opportunity was lost to maintain the efficiency of the motive machinery and its dependencies by intelligent adjustments at the proper time. The devotion to duty of officers and men and the willing co-operation of all in striving to maintain the vessel's speed and efficiency merit the greatest praise.

U. S. S. OREGON TAKING HER POSITION IN LINE AT THE NAVAL REVIEW, NEW YORK.

Life below the protective deck of the Oregon after March 6, 1898, was a life of hardship and toil, a life spent in a heated atmosphere where the roaring of the furnaces and the leaping of the massive engines might well have afforded some excuse for confusion and lack of purpose among those whose days and nights were passed there. Not so, however. These

*From the Journal of the American Society of Naval Engineers.

†Dispatch from Admiral Dewey announcing the successful termination of another long ocean voyage of the *Oregon*, from New York to Manila, via Cape Horn, a distance of 20,000 nautical miles. The article here printed refers to the famous voyage of the Oregon from the Pacific to the Atlantic coast.—Ed.

men of the engineer department rose equal to the emergency and went about their duty calmly, earnestly and with wonderful intelligence. The organization was perfect and the execution of the task set faultless. On more than one occasion when the labors of the men before the furnaces seemed to them to go for naught, and they felt all but discouraged because the steam would not "go up," the engineer officers, discarding their uniforms, jumped among them, fed the furnaces with their own hands, and, by force of this example, so encouraged the firemen that, with cheers, they redoubled their efforts, and the good ship sped through the water at a faster pace. This is the spirit that imbued the men of the Oregon, and this the work that brought to a successful end the most remarkable run ever made by a battleship.

The voyage was made in eight stages, as follows:

1st. From Puget Sound Naval Station to San Francisco.
2d. From San Francisco to Callao.
3d. From Callao to Port Tamar in the Straits of Magellan.
4th. From Port Tamar to Punta Arenas.
5th. From Punta Arenas to Rio de Janeiro, Brazil.
6th. From Rio de Janeiro to Bahia, Brazil.
7th. From Bahia to Barbadoes.
8th. From Barbadoes to Jupiter Inlet, Florida.

The ship was coaled at Puget Sound Naval Station, San Francisco, Callao, Punta Arenas, Rio de Janeiro and Barbadoes. The kind of coal used during each run is given in the accompanying performance table, as are also the distances run from port to port.

The complement of the engineer department was as follows:

Chief Engineer R. W. Milligan, U. S. N.
Passed Assistant Engineer C. N. Offley, U. S. N.
Assistant Engineer J. M. Reeves, U. S. N.
Assistant Engineer Frank Lyon, U. S. N.
Naval Cadet, Engineer Division, H. N. Jenson, U. S. N.
Naval Cadet, Engineer Division, W. D. Leahy, U. S. N.

Chief machinists	5
1st class machinists	3
2d class machinists	2
Yeoman	1
Boilermaker	1
Blacksmith	1
Coppersmith	1
Water tenders	6
Oilers	8
1st class firemen	14
2d class firemen	14
Coal passers	40

A total of officers and enlisted men of 94. It is interesting to compare this number with the total engineer force employed by the Union Iron Works upon the official trial trip of the Oregon, when the number on duty was 161 men.

The voyage may be considered to have ended when the ship dropped anchor at Jupiter Inlet on the night of May 24, and the record given here closes at that time. Still further honor awaited this wonderful ship, however. At 3:57 in the morning of May 25 the engines moved ahead slowly and the Oregon began her journey to Key West, where she arrived the following day shortly after 7 A. M.

Ordinarily, after a run of more than 14,500 knots, a great many repairs would be found absolutely necessary even to a cruiser, and several weeks would not be considered too long a time to spend in rehabilitating the engines and boilers of any ship after such extraordinary service. But the Oregon coaled, rapidly completed a few adjustments of machinery, repaired a few minor defects, and at 1:04 in the morning of May 29, less than three days after her arrival, steamed away from Key West to add her strength to that of our fleet off Santiago de Cuba.

Her part in the battle of July 3, 1898, which resulted in the annihilation of the Spanish fleet under Admiral Cervera, is now a matter of history. If any further evidence is needed than that already given of the qualities of the Oregon, and of her personnel, the following quotations will undoubtedly furnish it:

"The Oregon, steaming with amazing speed from the commencement of the action, took first place." (Official report of Rear Admiral W. T. Sampson, U. S. N., upon the battle of July 3, 1898.)

"The fine speed of the Oregon enabled her to take a front position in the chase, and the Cristobal Colon did not give up until the Oregon had thrown a 13-in. shell beyond her. This performance adds to the already brilliant record of this fine battleship and speaks highly of the skill and care with which her admirable efficiency has been maintained during a service unprecedented in the history of vessels of her class." (Ibid.)

"The Oregon, having proved *vastly faster than the other* battleships, . . . continued westward in pursuit of the Colon." (Official report of Commodore W. S. Schley, U. S. N., upon the battle of July 3, 1898.)

"I cannot close this report without mentioning in high terms of praise the splendid conduct and support of Captain C. E. Clark of the Oregon. Her speed was wonderful and her accurate fire splendidly destructive." (Ibid.)

"The two remaining vessels were now some distance ahead, but our *speed had increased to 16 knots*, and our fire . . soon sent . . the Viscaya to the shore in flames." (Official report of Captain C. E. Clark, U. S. N., commanding the Oregon, upon the battle of July 3, 1898.)

"As these vessels (the Spanish) were so much more heavily armored than the Brooklyn they might have concentrated upon and overpowered her, and consequently I am persuaded that, but for the way her officers and the men of the Oregon steamed and steered the ship and fought and supplied her batteries the Colon, and perhaps the Viscaya, would have escaped." (Ibid.)

"The Oregon was keeping up a steady fire and was coming up in the most glorious and gallant style, *outstripping all others.* It was an inspiriting sight to see this battleship, with a large white wave before her, and her smokestacks belching forth continued puffs from her forced draft. We were making fourteen knots at the time, and the Oregon came up off our starboard quarter at about 600 yards and maintained her position, though we soon after increased our speed to 15 knots, and just before the Colon surrendered were making nearly sixteen." (Official report of Captain F. A. Cook, U. S. N., commanding the Brooklyn, upon the battle of July 3, 1898.)

U. S. S. *OREGON.*

Bunker capacity, 1,590 tons of 43.5 cubic feet to the ton.

Date.	Hours.	Speed. Knots pr. hour.	Total coal expenditure for 24 hours. Tons.	Knots.		Coal endurance.		Months out of dock.	Wind		Sea.	Boilers in use.	Kind and quality of coal.	Total knots logged.	Remarks.
				Per day.	Per ton of coal.	In days.	In knots.		Direction.	Force.					
March 6–9, 1898	72.	11.48	69.74	275.57	3.95	22.7	6280.	⅔	11	4	S. to M.	3 main.	Comox; good.	826.7	Puget Sound to San Francisco.
Mar 19–Apr 4, 1898	375.	10.9656	61.80	263.744	4.267	25.7	6784.	1	6	3	S. to M.	3 main.	Comox; good.	4,112.1	San Francisco to Callao.
Apr. 7–16, 1898	213.6	11.935	88.73	286.45	3.288	17.9	5228.	1⅔	3	3	S. to M.	3 main.* / 4 main.*	Cardiff; good	2,549.4	Callao to Port Tamar.
Apr. 17, 1898, (8 A. M. to 5 P. M.)	9	14.6	176.64	350.4	1.98	9.0	3148.	2	Var.	2	S.	4 main.	Cardiff; good.	131.4	Port Tamar to Punta Arenas. Steaming through Strait of Magellan. Blowers in open fire-rooms. Av. I.H.P. = 6,450.
Apr. 21–30, 1898	221.25	10.159	70.30	243.78	3.467	22.6	5512.	2	5	3	S. to M.	4 main.	Cardiff; good.	2,247.7	Punta Arenas to Rio de Janeiro. Following U. S. S. *Marietta* and suiting speed to hers.
May 5–8, 1898	74.25	10.09	74.85	242.16	3.234	21.2	4942.	2⅓	2	3	S.	4 main.	English bituminous; fair.	749.7	From anchor off Rio to Bahia, Brazil.
May 10–17, 1898	193.25	11.544	77.00	276.77	3.594	20.6	5714.	2⅔	9	3	S.	4 main.	English bituminous; fair	2,228.0	Bahia to Barbadoes.
May 19–24, 1898	141.5	11.773	81.14	282.55	3.482	19.5	5536	3	9	3	S.	4 main	English and Welsh bituminous; fair.	1,665.9	Barbadoes to Jupiter Inlet, Florida.

* Half time.

Total knots of above performances	14,510.9
Total hours of above performances	1,299.85
Total tons of coal used, above performances	4,009.38
Knots per hour (all runs)	11.16
Knots per ton (all runs)	3.61

Greatest displacement, April 7	11,857 tons.
Least displacement, March 9	10,417 "

The engineer officers on board the Oregon during this memorable engagement, and their stations, were as follows:

Chief Engineer R. W. Milligan, in charge of machinery.
Passed Assistant Engineer C. N. Offley, starboard engine-room.
Assistant Engineer J. M. Reeves, port engine-room.
Assistant Engineer F. Lyon, in charge of fire-rooms.
Naval Cadet H. N. Jenson, after hydraulic pump-room.
Naval Cadet W. D. Leahy, forward hydraulic pump-room.
Acting Assistant Engineer T. C. Dunlap, starboard engine-room.

The number of enlisted men in the engineer department was 114.

Thus we see that the Oregon, four and one-half months out of dock, with an engineer complement of 121,* was able, almost immediately after a voyage of more than 15,000 miles, to go into battle and fight sucessfully, while making a speed of 16 knots per hour. Her contract trial speed was 16.791 knots per hour, and the engineer complement at that time 161, as previously stated.

The record of this peerless battleship and the efficiency of her officers and crew stand unequaled in the history of the world's navies, and shed new luster upon the skill of American shipbuilders and mechanics, and upon the intelligence and devotion to duty of the personnel of the American Navy.

A table of performances is given herewith.

*This number is an increase of 27 over those on board during the voyage from California to Florida; the additional officer and men having been ordered on board after the arrival at Key West, to meet the war conditions.

MARYLAND STEEL CO.'S SHIPBUILDING PLANT AT SPARROW'S POINT, MARYLAND.

The ship yard of the Maryland Steel Company, at Sparrow's Point, Md., which was built as an adjunct to the steel plant in 1891, and which, in 1895, on account of scarcity of marine work, went into bridge and structural work, resumed ship building operations last fall, securing for the first contract three of the torpedo-boat destroyers provided for in the Naval programme of May, 1898.

The yard, which has a water frontage of about 2,000 ft., consists of a ship shed, machine and erecting shop, blacksmith shop, copper shop, joiner shop and boiler shop, and a complete lumber working plant, with Sturtevant dryer. The foundry and pattern shops are the same as used for the other branch of the works and are about a half mile from the ship yard.

Plans are projected for a dry dock, and it is expected that work on this will be hurried.

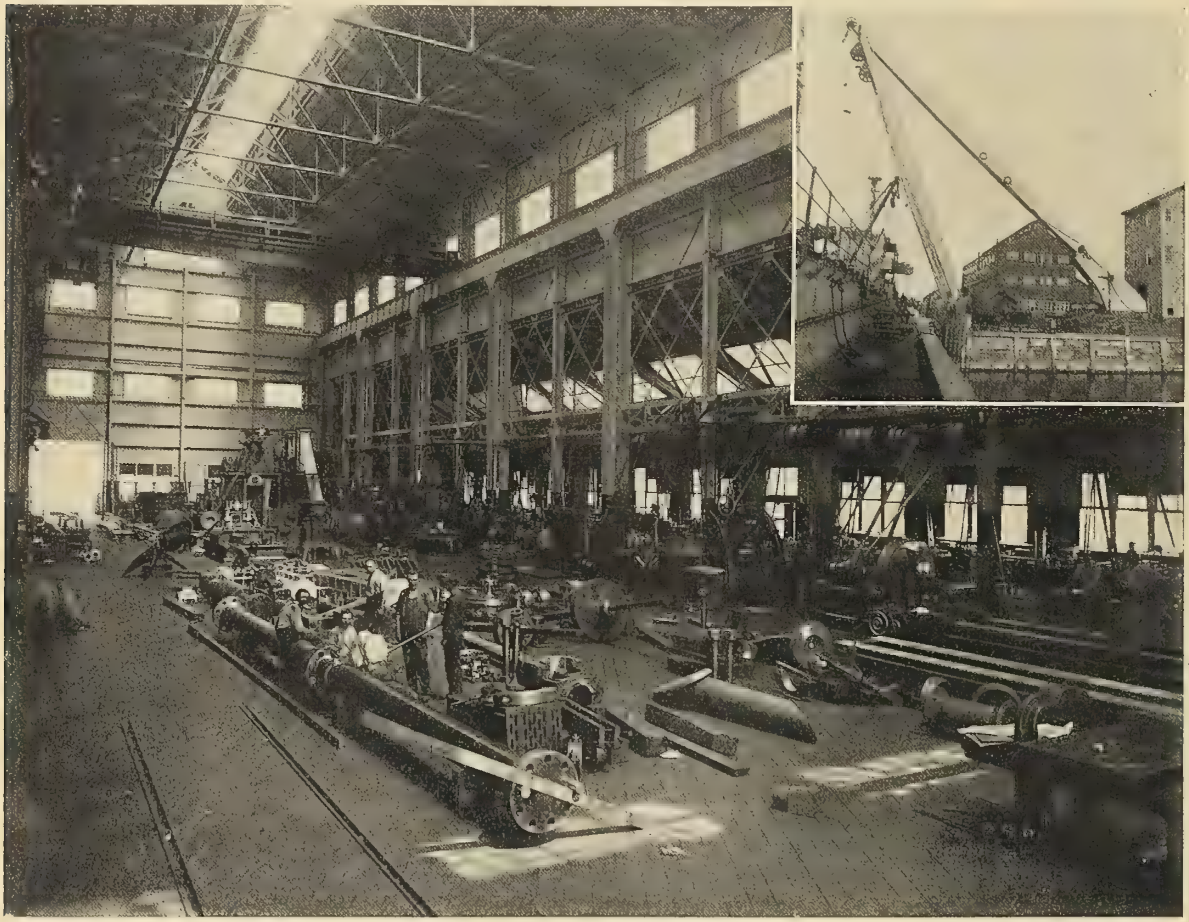
A peculiarity of the plant, as originally laid out, was that no mould loft was provided, the fairing being done on large scale drawings in the draughting rooms. The offsets were given to the loftsman, instead of in figures or on poles, on long strips of tough paper, and transferred directly to the scrieve board. These strips, in rolls, are preserved, so that the complete mould loft dimensions are at any time available. When operations at the yard were resumed the joiner shop floor was utilized for a mould loft for some of the vessels, but the old method of fairing in the drawing room has been restored for more recent contracts.

The iron gauge system for bending frames is used instead of wood moulds. When the frames have cooled off they are ready to be put in place, the punching having been done from the straight bar before heating.

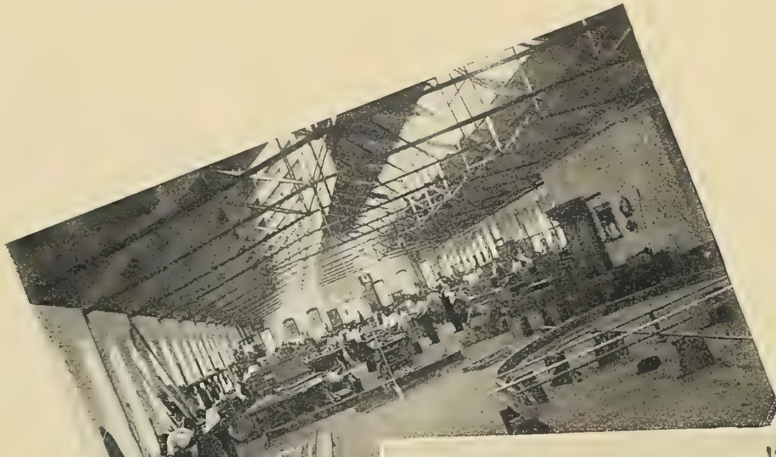
The heating furnaces are shown in one of the accompanying photographs. The plate furnace is built in the usual way of brick, and the angle furnace of plates, cylindrical in form. Oil is used for fuel, with much success, the advantages being quick firing and the regulation or stopping off entirely of the heat, at any part, thus rendering unnecessary the protection of scarfs and thin places with clay, as in the old method. The fires are closed off each night and started an hour before the yard begins next morning.

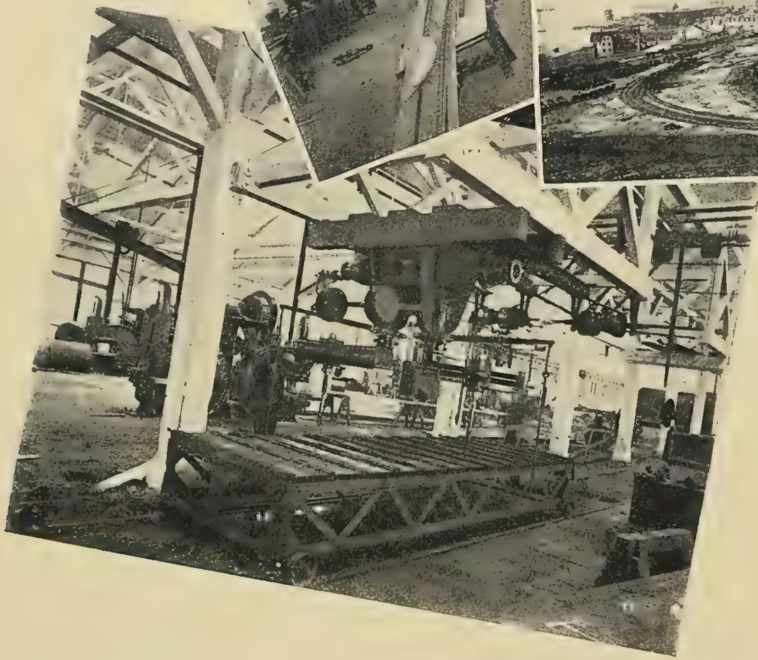
There is a galvanizing tank for the smaller work, but most of the galvanizing will be done by contract. The cleaning of plates is accomplished by the recently established "sand blast process," thus saving the plates from the dangers of pickling.

The shops and stock yard are fitted with electric traveling cranes, and there is a complete hydraulic

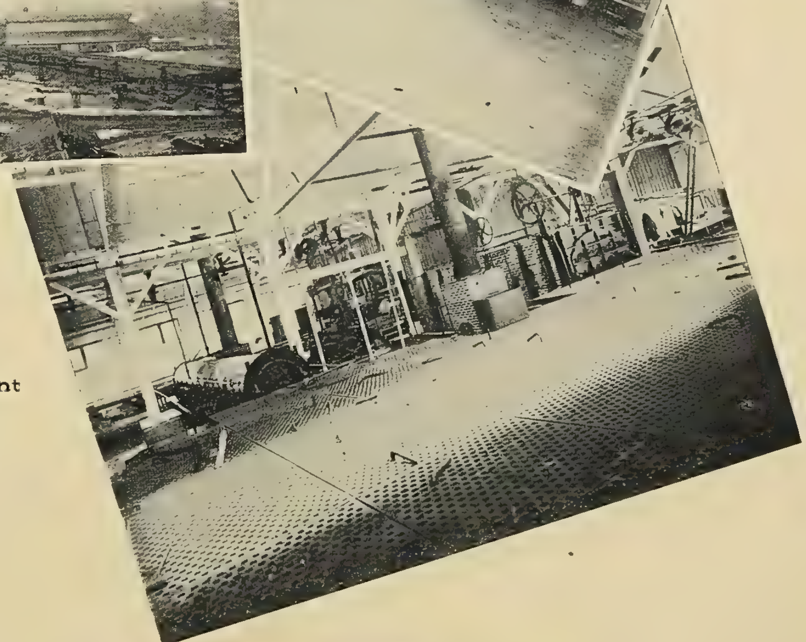


VIEWS SHOWING INTERIOR OF ERECTING SHOP AND 125-TON SHEERS, WITH TURRET STEAMER ALONGSIDE.





Views at Sparrow's Point Shipyard.



Interior of joiner shop.

Interior of shipshed.

General view of yard from furnaces—rail mill and Bessemer plant in foreground.

Radial countersink in shipshed.

Angle and plate furnaces.

and pneumatic system for riveting, punching, drilling, caulking, and similar operations.

Punches, sheers, planers and all machines in the ship shed are to be driven independently with electric motors. Some are driven independently now by steam, but motors have been ordered for all. This enables over-time on single machines to be carried out at small cost, and permits different speeds on particular or ordinary work, to say nothing of the advantage in case of a break down in the engine room.

The foundry, too, is provided with an electric traveling crane, the capacity of which is 50 tons, also four 15-ton hydraulic jib cranes, and hydraulic elevators.

The sheers, shown in one of the illustrations, were used to transfer the 19-in. Krupp gun for the World's Fair from the steamship in which it crossed the ocean to the special flat car built for the transportation of the gun from the coast to Chicago. This sheers has been tested to a maximum load of 146 tons net. Hydraulic power is used to operate the sheers, at a pressure of 1,600 lb. to 1,800 lb. per square inch.

The first of the contracts secured, as already noted, was for the construction of three torpedo-boat destroyers for the Navy, the names of which are *Truxtun*, *Whipple* and *Worden*, officially known as Nos. 14, 15 and 16, respectively. These boats, which are contracted for on the builder's design, resemble closely the Spanish destroyers *Furor* and *Terror*, and are 248 ft. long, 22 ft. 6 in. beam and 6 ft. draught on the load water line, with corresponding trial displacement of 433 tons. They will be fitted with triple-expansion engines, with cylinders 23 in., 34 in. and two 37 in. dia. and 22 in. stroke. With 240 lb. steam pressure they are expected to indicate 8,300 horse power and attain a speed of 30 knots.

In the yard the outside plating is now being put in place on a twin-screw freight and passenger steamer for the New Haven Steamboat Company, to be used for the Long Island Sound service. This steamer, which is practically a duplicate of the *Richard Peck*, is 325 ft. long over all; 48 ft. beam, moulded; 65 ft. over guards, and 17 ft. 9 in. deep, moulded. Her engines are triple-expansion, having cylinders 24 in., 38 in. and 60 in., with a stroke of 30 in. and steam pressure of 170 lb.

Work is also progressing on a seagoing tug for the Baker-Whiteley Company, of Baltimore, in dimensions: Length, 112 ft. between perpendiculars, 125 ft. over all; moulded breadth, 24 1-2 ft., and depth, 14 ft. Her engines will be triple-expansion, with cylinders 14 1-2 in., 23 1-2 in. and 39 in. dia. by 28 in. stroke; steam pressure, 175 lb., and about 800 I. H. P. This tug will carry powerful wrecking and fire pumps, an electric light plant, capstan and steam steering gear.

Two single-screw steamers for the Boston Tow Boat Company have been laid down. The dimensions of these boats are: Length, 324 ft.; beam, 47 ft., with a dead weight carrying capacity of 4,000 tons, to be fitted either as tramps or colliers. The engines are triple-expansion, with cylinders 21 in., 35 in. and 56 in., by 42 in. stroke and 1,400 I. H. P. Steam is supplied by two single-ended Scotch boilers. They will be fitted with complete outfit of hoisting winches, towing machines, and are to have the highest American classification.

In addition to these boats, there is also contracted for and building a floating dry dock for the Navy, to be 138 ft. wide and 545 ft. long, capable of taking on steamers even of the *Campania* class.

At present the shapes for vessels are rolled at the company's plant at Steelton, Pa., but the final plan will be to roll plates and shapes at Sparrow's Point.

The original and main part of the plant, to which, as has been said, the Marine Department was an addition, consists of foundries, pattern shop, boiler and machine shop, four blast furnaces, Bessemer plant, and rail mill with capacity of 1,600 tons of steel rails per day. Though the Bessemer plant is entirely independent of the blast furnaces, the general practice is to use the metal, transported in ladle cars directly, without reheating. The company at present, in addition to contracts in this country, is shipping rails to Ireland, India, China and Australia.

The ore used is received at the company's piers from Santiago de Cuba and Cartagena, Spain. The wharves are fitted with the coal loading device of the Link Belt Engineering Co. type.

Another contract, on which considerable interest centers, is one of the War Department for ten mounts for 12-in. rifled seacoast mortars.

The officers of the company are: President, F. W. Wood; General Agent, R. K. Wood; and the ship yard is in the hands of: General Manager, A. G. Wilson; Assistant General Manager, Rodgers Wilson, and H. A. Magoun, marine engineer. The Navy Department is represented by Wm. H. Varney, U. S. N., superintending constructor, and D. C. Redgrave, U. S. N., inspector of machinery.

For the foregoing particulars and the fine photographs of the yard and shops we are indebted to C. B. Brewer, a member of the staff of the resident U. S. naval constructor.

VIBRATIONS OF STEAMSHIPS AND METHODS OF BALANCING MARINE ENGINES—III.

BY C. H. PEABODY, B. Sc.

Mr. Yarrow has employed a method of balancing an engine with bob-weights, which can best be explained by certain simple preliminary examples, as in his

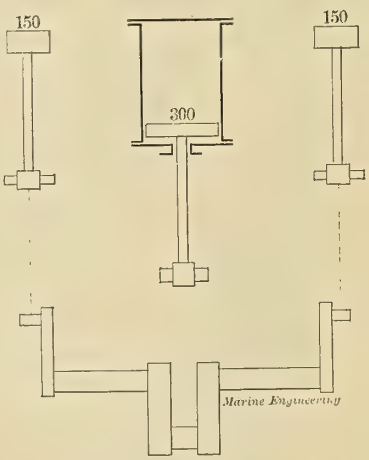


FIG. 9.

exposition of that method. Let Fig. 9 represent a single-cylinder engine and its crank shaft, which has two overhung cranks at the ends. At equal distances from the cylinder are bob-weights that are driven by the overhung cranks. The weight of each bob-weight with its rod and crosshead is half the weight of the piston, piston-rod and crosshead, and each bob-weight connecting-rod has half the weight of the engine connecting-rod. With the overhung cranks opposite the engine crank the system of counterweighting is almost perfect, for it takes care of the transverse throw of the connecting-rod as well as the vertical acceleration of the reciprocating parts. This system of balancing would be perfect with a slotted crosshead; with a short connecting-rod the inequality of the accelerating forces at the top and bottom of the stroke is appreciable but is seldom of importance. It is not necessary to have the bob-weights equidistant from the engine cylinder; they may be at unequal distances, as in Fig. 10, provided their weights are properly proportioned. In Fig. 10 the right hand bob-weight and attached parts has half the weight of the left hand bob-weight and attached parts, for it is twice as far from the engine cylinder. The right hand overhung crank in this case should also have half the weight of the left hand crank, to preserve the balance of the crank shaft. In any case it will be sufficient to make the weights of the bob-weights (and

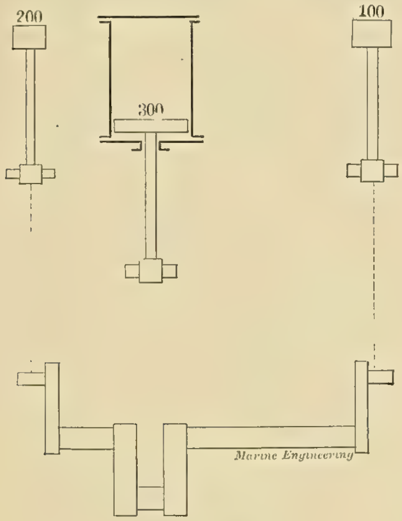


FIG. 10.

attached parts) inversely proportional to their distance from the cylinder of the engine. The connecting-rods should also have their weights inversely proportional to their distances if the transverse throw is to be balanced.

But it is not necessary to make the length of the overhung cranks the same as that for the engine itself. If the bob-weights in Fig. 9 are each made as heavy as the piston and its attached parts, then the overhung crank can be made half as long as the engine crank. For either Fig. 9 or Fig. 10 the length of an overhung crank and its bob-weight may be varied at will, provided that after such a transformation the product obtained by multiplying together the length of the crank and the weight of the bob-weight (and attached parts) is equal to the product of the original length and the original weight.

The preceding discussion affords the basis of the method of balancing proposed by Mr. Yarrow. He first chooses two convenient places near the ends of his engine at which he proposes to place all the bob-weights, or, rather, the equivalent of them. In Fig. 11

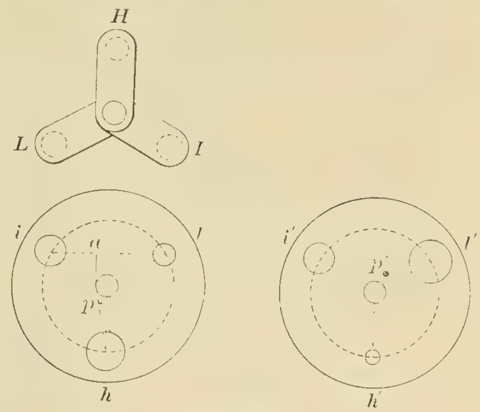


FIG. 11

let the cranks for the high-pressure, intermediate and low-pressure pistons be represented by *H*, *I* and *L*. Let *h i l* represent a circular disk clamped to the shaft forward of the engine, and h^1 i^1 l^1 be a similar disk abaft of the engine; all the diagrams in Fig. 11 are supposed to be viewed by a man who stands in front of the high-pressure cylinder and looks aft. Let us consider first the high-pressure piston. To counterbalance it we may use two cranks with bob-weights, which may be one forward of the engine and one aft. The forward bob-weight will be the larger, as it is nearer the cylinder under consideration. For counterbalancing the vertical accelerating force we may use instead, if we choose, two weights, as *h* and h^1, which shall be placed opposite the crank *H*, one on the forward circular disk and one on the after disk. The sum of the weights *h* and h^1 will be equal to the weight of the reciprocating parts of the high-pressure cylinder, and their individual weights will be inversely proportional to the distance of the high-pressure cylinder to the circular disks. Of course if we finally use such revolving counterweights, we must accept the transverse throw at half stroke; however, the assumption of revolving counterweights is merely a device for working out the problem, and bob-weights will be used in the end. On the diagram the revolving counterweights are represented by circles with areas proportional to their weights. The intermediate piston can be counterbalanced by the two weights *i* and i^1; *i* being slightly the heavier because the intermediate cylinder is nearer the forward circular disk. Again, the low-pressure piston can be counterbalanced by the weights *l* and l^1; the latter being the largest weight on either disk, because the low-pressure piston is large and is near the circular disk. The circular disks may be assumed to be symmetrical, so that they are individually in balance, but one disk with its counterweights will of course be out of balance. To find the effect of centrifugal force acting on any unbalanced revolving body it is sufficient to know its weight, the position of its center of gravity, and, of course, the number of revolutions per minute. The last term need not, however, be considered for our present purpose, as a proper counterbalancing will be equally efficacious at all speeds. Let us suppose now that p is the center of gravity of the system of these weights at h, i and l. This can be found by drawing the line $i\ l$ joining the centers of the weights i and l, and dividing it at a, into parts which are inversely proportional to the weights at i and l; and then by joining a to the center of h and dividing the line $a\ h$ into parts that are inversely proportional to $i + l$ and h. In like manner p^1 is the center of gravity of the system of the weights i^1, l^1 and h^1 on the aft disk. We may therefore counterbalance the engine by placing at p a weight equal to $h + i + l$, and at p^1 a weight equal to $h^1 + i^1 + l^1$. If we use that method, however, we shall have an undesirable cross throw when either the weight at p or the weight at p^1 is half way between the top and bottom of its revolution. To avoid this cross throw it will be necessary to use bob-weights. The forward bob-weight will have the center of its crank pin at p and the reciprocating parts will have a weight $h + i + l$; in like manner the after bob-weight will weigh $h^1 + i^1 + l^1$, and p^1 will be the center of the crank pin. If the weight $h + i + p$ is considered too large for convenience, half that weight may be used, provided the length of the crank be doubled; or the crank may be made any desirable length provided the weight be proportionally reduced. So also may the crank for the after bob-weight be made any desirable length by changing the weight to correspond. In general it will be found more convenient to use eccentrics to drive the bob-weights instead of cranks; this, however, will affect details of construction only.

For the sake of simplicity the statement for Yarrow's method takes account of the piston only; but the valves and valve gear for a marine engine have considerable weight, and it is desirable to include them in the balancing of the engine. In dealing with the valve gear Mr. Yarrow assumed the go-ahead eccentric to drive the valve and its rod, also half the link and one eccentric-rod. The backing eccentric was assumed to drive half the link and one eccentric-rod. He had thus in all nine sets of reciprocating parts, namely, three pistons and connected parts, three valves with rods and half links and three half links and eccentric-rods. This gave him nine counterbalancing weights at the forward location for counterbalancing, and nine at the after plane. The method, however, differed from that represented by Fig. 11 only in having more counterbalancing weights to reduce to one weight at the center of gravity of the system, and this meant only a little more calculation in the determination of the center of gravity.

For a special case of the engine for a torpedo boat Mr. Yarrow found that 740.25 lb. were required at the forward plane for counterbalancing, the center of gravity being 1.04 of an inch from the center of the shaft. The after weight was 1,178.15 lb., and its center of gravity was 0.28 of an inch from the center of the shaft. Mr. Yarrow used for the forward bob-weight 413 lb. with an eccentricity of 1 7-8 in., and for the after bob-weight 134 lb. with an eccentricity of 2 1-2 in. The total weight added was consequently only 547 lb., and the bob-weights were found to give little inconvenience in the design or running of the machinery. To reduce the task of counterbalancing his engine Mr. Yarrow first counterbalanced the cranks before proceeding to discuss the reciprocating parts. In practice this method has been found to give very satisfactory results when applied to a torpedo boat,

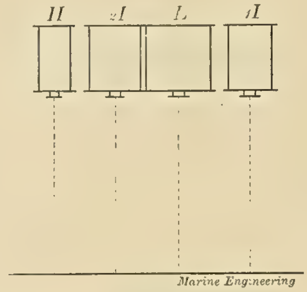


FIG. 12

which showed dangerous vibrations when the engine was unbalanced, and scarcely any when the engine was balanced.

This method when applied to the balancing of large engines is liable to demand very large bob-weights and large eccentrics for driving them. Schlick says that such a set of bob-weights for a certain engine which indicated 7,000 horse power weighed in all 44 tons, even though very large eccentrics were chosen, one eccentric having 12 in. eccentricity and the other 20 in. It is needless to say that the system was not applied to that engine.

Schlick has devised a very ingenious way of counterbalancing a marine engine when four cylinders are employed, which method virtually treats two of the pistons as bob-weights for counterbalancing the other two. He first suggests that the two large cylinders for a four-cylinder engine be placed in the middle and the smaller cylinders at the ends. Thus for a quadruple-expansion engine he would use the arrangement shown by Fig. 12, the cylinder beginning at the forward end of the engine being in the order of high-pressure, second intermediate, low-pressure and first intermediate. The chief difficulty of such an arrangement seems to be the large amount of piping

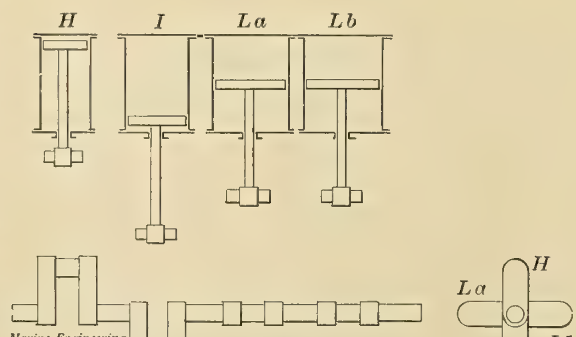


FIG. 6

needed, since the exhaust from the high-pressure cylinder must be led the whole length of the engine to reach the first intermediate cylinder; and the exhaust from the first intermediate cylinder must be led nearly as far to reach the second intermediate cylinder. A four-cylinder triple-expansion engine with two low-pressure cylinders can be similarly arranged with the two large cylinders in the middle. If it is considered desirable, the usual arrangement

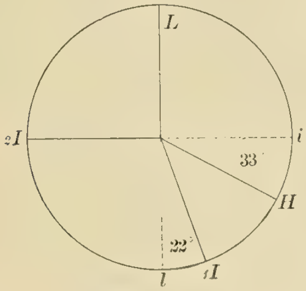


FIG. 13.

shown by Fig. 6 can be used, the order being, high-pressure, intermediate and then the two low-pressure cylinders, and the method may still be used.

Having the engine arranged as in Fig. 12, Schlick proposes that the cranks for the two inside cylinders be placed at right angles as indicated on Fig. 13, and then says that for the customary proportions for such a quadruple engine the high-pressure and first intermediate cranks will be at *H* and *1 I*, the first 33 deg. from a horizontal line and the second 22 deg. from a vertical line. These angles occur with an engine which has the following proportion of reciprocating parts:

High-pressure	1.
First intermediate	1.177
Second intermediate	1.261
Low-pressure	1.64

It will be seen that the succession of cranks starting at the high-pressure crank is as follows:

High-pressure to second intermediate	147°
Second intermediate to low-pressure	90°
Low-pressure to first intermediate	158°

It may be expected that the engine will give a very smooth turning motion to the shaft, almost as good an effect as the arrangement shown by Fig. 6. The

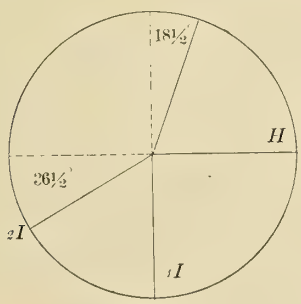


FIG. 14.

effect of the engine in starting cannot be considered so satisfactory, since the high-pressure crank is only 35 deg. from the first intermediate crank.

If the two outside pistons can be used as bob-weights for the inside pistons, then conversely the inside pistons may be made to serve as bob-weights for the outside pistons. With the same proportions for the engine Schlick suggests the arrangement shown by Fig. 14. Here the high-pressure and first intermediate cranks are at right angles, while the second intermediate crank is 36 1-2 deg. from the horizontal and the low-pressure crank is 18 1-2 deg. from the vertical. The succession of crank is therefore

High-pressure to second intermediate	143½°
Second intermediate to low-pressure	145°
Low-pressure to first intermediate	161½°

This would appear to give a smoother turning effect than the previous arrangement and to give a better arrangement for starting. But for that matter it appears that a proper arrangement of by-pass valves for supplying steam to the larger cylinders ought to allow the engineer to start with certainty from any position of the engine.

To determine the position of the two outer cranks for the first arrangement shown by Fig. 13, we may proceed as follows: Assume that there are symmetrical disks placed at the positions where the out-

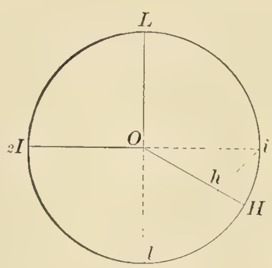


FIG. 15

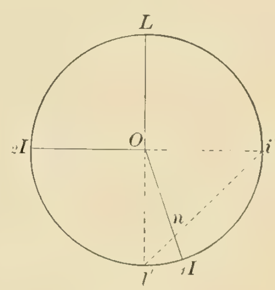


FIG. 16

side cranks (high-pressure and first intermediate) are to come, and find the proper counterweights to be attached to these disks to counterbalance the two inside pistons. Fig. 15 may represent the forward disk and Fig. 16 the after disk; the positions for the second intermediate and low-pressure cranks are marked on the disks for reference. The counterbalance weights for the second intermediate piston will be at *i*, Fig. 15, and at *i'*, Fig. 16, and will be inversely proportional to the distance of the second intermediate cylinder from the high-pressure and first intermediate cylinder, or, what amounts to the same thing, from the assumed counterbalancing disks. The counterweights for the low-pressure piston will be at *l* and *l'*. The sum of the weights at *i* and *i'* must be equal to the weight of the reciprocating parts of the second intermediate cylinder, and the sum of the weights at *l* and *l'* must be equal to that for the low-pressure cylinder. Now, in Fig. 15, find the center of gravity of the weights at *i* and *l* by dividing the line joining those parts inversely proportional to the weights at *l* and *i*. The center of gravity *h* is the place where a weight equal to the sum of the weights at *i* and *l* can be placed to counterbalance both the inside pistons. In like manner join i' and l', in Fig. 16, and divide the joining line at n inversely proportionally to the weights at i' and l'. Then n is the place where a weight equal to the sum of those at i' and l' can be placed. The high-pressure crank will be at H on the prolongation of a line drawn from the center of the shaft through h. To find the proper weight of the high-pressure reciprocating parts multiply the counterbalance weight at h by the length of the line $o\ h$ and divide by the length of the line $O\ H$. The first intermediate crank is at $1\ I$ on the line $O\ n$ produced, and its weight is found by multiplying the counterbalance weight at n by $O\ n$ and dividing by the radius of the crank $1\ I$.

A similar construction and calculation can be made for the arrangement shown by Fig. 14, where the counterbalance disks must be assumed to be at the places where the middle cranks are to come. Then counterweights are determined for the high-pressure and first intermediate reciproacating parts separately and therefrom single counterweights can be found, which will indicate the position of the inside cranks. The determination of the weights of the reciprocating parts for the inside cylinders is then to be determined as were those for the outside cylinders in the preceding statement for the arrangement of Fig. 13.

If the weights determined for those reciprocating parts which are treated as bob-weights cannot conveniently be used, then the counterbalancing will be imperfect to the extent of the difference between the determined weights and the weights that must be used.

Schlick does not appear to take account of the valves and valve gears in his method of counterbalancing engines. Of course there would be no great difficulty in dealing with the valves and gears for those cylinders whose cranks are at 90 deg.; the difficulty comes in trying to deal with the valves and gears for those cylinders whose reciprocating parts are treated as bob-weights. The only way appears to be to first balance the engine without considering the valves and gears and then add the latter and find how much lack of balance may exist. If the balance seems to be too imperfect, there seems to be no way of improving it except by trial, for of course the eccentrics must be in the proper relative position compared with the cranks to give the proper angular advance.

Though Schlick does not mention the application of his process to four-cylinder triple engines like those shown by Fig. 6, it is evident that it may be used to improve the running of such an engine, if not to give complete balance. To give complete balance it will probably be necessary to give unequal weights to the low-pressure pistons. If that cannot be done, the same result can be attempted by changing the weights of the high and intermediate cylinders.

It is interesting to note that the British cruiser *Terrible* had the cranks for a four-cylinder triple-expansion engine arranged as in Fig. 6, and that violent vibrations were found to occur when running at nineteen knots. The engines were tried with several arrangements of the cranks, settling finally on an arrangement which was very similar to that shown by Fig. 13 herewith.

AMERICAN SCHOOLS OF MARINE ENGINEERING AND NAVAL ARCHITECTURE.

UNITED STATES NAVAL ACADEMY AT ANNAPOLIS—DEPARTMENT OF STEAM ENGINEERING.

A Description of the Great National Educational Institution, with Special Reference to the Course of Instruction of the Recent Engineer Division of Naval Cadets.

BY CHIEF ENGINEER F. J. SCHELL, U. S. N.

The United States Naval Academy was founded in 1845 by the Hon. George Bancroft, Secretary of the Navy, in the administration of President James K. Polk. It was located at Annapolis, Maryland, on the land occupied by Fort Severn, which was given up by the War Department for the purpose. Previous to this the instruction of young naval officers had been carried on in a desultory manner at the Naval Asylum at Philadelphia, and at the Navy Yards at Boston, Norfolk and New York, a few Professors of Mathematics and Languages being detailed for this work. The Academy was formally opened under the title of the Naval School, on October 10, 1845, Commander (afterwards Admiral C. S. N.) Franklin Buchanan being the first Superintendent.

Various reasons led to the selection of Annapolis for the site of the Academy, prominent among which were its nearness to the seat of the national government at Washington, and what was then its excellent harbor, now unfortunately fallen quite into disuse for commercial purposes. Then, in addition, sectional lines had some weight, and as the other national Academy, that for the Army, was located in a northern state, it was only considered fair that the one for the Navy should be south of Mason's and Dixon's line.

The site is a beautiful one. Located in the angle made by the Severn river and the harbor of Annapolis proper, it has a water front on two of its sides about 1,800 yards in extent. The original plot contained about seven acres. This has been added to by reclaiming portions of the shore below low water mark, and by purchase, until at present fifty-three acres are included within the Academy walls. The ground rises gradually from the water to a maximum elevation of about twenty-five feet. The grounds are tastefully laid out, and the walks in the older portions are shaded by fine old walnut and maple trees.

The buildings for officers' and cadets' quarters have been erected at different times to meet the growing needs of the Academy, without following any well defined plan. Some of these, erected hurriedly on made ground, have been found unsafe, so that in 1895 a Board of Naval Officers, after a thorough and exhaustive examination of the subject, decided that the Academy had to be practically rebuilt, and on a scale commensurate with the importance of the Navy as one of the co-ordinate branches of the Nation's defense. An admirable design for rebuilding was worked out, utilizing such of the buildings as could be worked in harmoniously; the total expenditure involvel will be some eight to ten millions of dollars. Congress has

Cadet Quarters U. S. Naval Academy.

Boathouse and Ships on Severn River.

Building of Department of Steam Engineering.

EXTERIOR VIEWS AT THE U. S. NAVAL ACADEMY, ANNAPOLIS, MD.

at last consented to deal liberally with the Academy, about one and three-quarter million dollars have been made available, and the first contracts under the rebuilding plan, for a new Armory, Power House and the extension of the sea wall are about to be given out. When the plans are fully carried out the Naval Academy will be second to none in the world in its facilities for imparting instruction, thus insuring for the future the maintenance of the high standard for scholarship, practical knowledge and efficiency that its graduates have always had in the past.

The students at the Naval Academy are styled Naval Cadets, and there are allowed at the Academy one for every Member and Delegate of the House of Representatives, one for the District of Columbia and ten at large. The course is six years. Of these six, four are spent at the Academy and two at sea. At the expiration of the latter the cadets return to the Academy for final graduation, after which they are commissioned in the lowest grades of their corps. As there are thus always two classes at sea, the number at the Academy is always, at least, that many less than the number of Representatives. In addition there are nearly always a few districts in which Representatives have not made appointments, so that the usual number at the commencement of the Academic year, October 1, does not vary much from two hundred and sixty. The last graduating class of fifty-five members had, in addition to the six appointed at large, representatives from twenty-two states. Kentucky headed the list with a representation of five. Ten states had each a single representative.

Candidates for admission are nominated by the Representatives of the different Congressional Districts, and appear for examination on May 15 and September 1 each year. The candidate must be between fifteen and nineteen years of age. He is subjected to a rigid physical examination, and a mental one which the youth who has had a good high school education should be able to pass without special difficulty. Those who receive 62.5 per cent. of the maximum mark in all branches are considered as having passed satisfactorily, and are appointed Naval Cadets by the Navy Department.

The life of the cadet is eminently a busy one, the daily routine being about as follows: Reveille at 6 A. M., when he must turn out, and in the succeeding half hour dress and tidy up his room. Then comes morning roll call, followed by breakfast from 6:45 o'clock to 7:30 o'clock. At 7:30 A. M. sick call, when those in need of medical attention proceed to Sick Quarters to see the Medical Officer of the day. From 7:55 o'clock to 10 o'clock and 10:10 A. M. to 12:15 P. M. are the first and second study and recitation periods. At 12:30 o'clock dinner, for which one hour is allowed. Afternoon recitations are from 1:55 o'clock to 3:55 o'clock, at which latter time recitations end for the day. From 4:10 P. M. to 5:45 P. M. is the drill period, and it is during this period that the cadet receives his practical instruction in the duties of the enlisted man as well as the officer on board ship. In the evening from 5:45 o'clock to 6:30 o'clock is a recreation period. At the latter hour the cadet has his supper. From 7:30 o'clock to 9:30 o'clock is the period for evening studies, and at 10 P. M. "taps," when all hands must turn in.

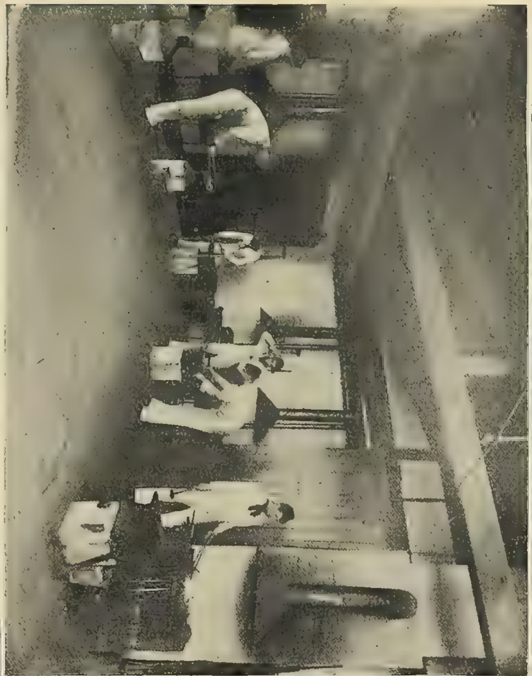
This is practically the routine for five days in the week throughout the Academic year. Saturday morning the first period is for recitations and the second is for drills. Saturday afternoon and evening are free from drills and recitations and are the principal recreation times of the cadet. It is then that he can visit his friends in the city of Annapolis, or the families of officers in the yard. On Saturday evenings the cadet hops are given, lasting from 7:30 o'clock to 10 o'clock. About ten of these are given during the season, and they are largely attended, visitors from as far as Philadelphia or New York being in frequent attendance for the hop. The brilliant function of the year is, of course, the hop given to the graduating class in June, at which at least one thousand guests are expected and welcomed.

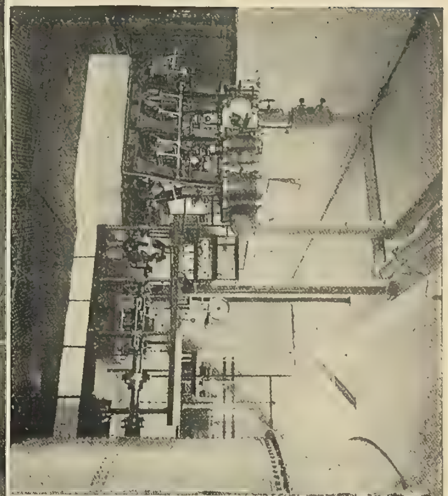
Although the cadets' time is well occupied by study, recitations and drills, they still manage to get opportunity for sports and, occasionally, for some of the pranks of their college compatriots. There is always, each in its proper season, a football, baseball and track team and a boat crew in training. Games, which take place on Saturday afternoon, are arranged with different college teams, and the cadets, owing to their pluck and excellent physical condition, are quite uniformly successful. Last year's football team was beaten once, and then by Princeton University. That the cadets indulge in pranks, the illustration of the "Burial of Math." (which takes place when the course in mathematics is finally ended at the end of the first term in the first class year) will show.

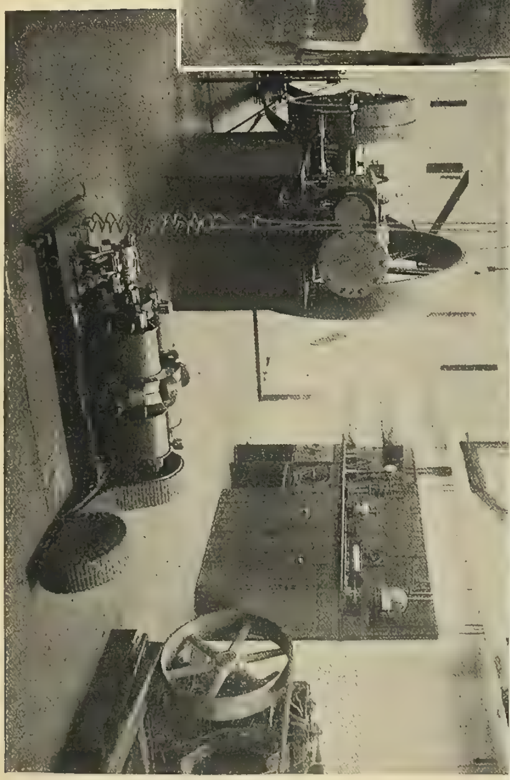
The cadets are divided into classes as follows: Those in their first year constitute the fourth class; second year, third class; third year, second class, and fourth year, first class. Class lines are closely drawn; certain seats and walks in the grounds belong to certain classes, and unhappy the lot of the lower classman found occupying either by the "rightful" owners.

The drills and practical exercises are of many and various kinds, and during the first three years are the same for all cadets. They are drilled as a Battalion of Infantry and of Artillery; are exercised in boats under oars and sails, and have the practical handling of steam launches; have fencing, swimming, boxing, gymnastics, dancing, and cane and broad sword exercises, and also target practice, both with small arms and great guns. The view here printed of the battalion scaling the wall is one of the features of infantry drill. These drills and exercises, many of which take place in the open air, in addition to imparting a vast amount of practical instruction, are an excellent thing for the physical well being of the cadets, "hard as nails" being not at all a misnomer for their physical condition.

The Superintendent is a line officer of the Navy, not below the rank of Commander. Heads of departments and instructors are, with a few exceptions, naval officers, detailed by the Navy Department at the request of the Superintendent, who thus spend their three years' tour of shore duty in instructing in the different Academic Departments. The head of the Departments of Steam Engineering and Drawing is a Chief En-







Experimental Steam Engine.

Blacksmith's Shop—Dept. Steam Engineering.

Pattern Shop—Dept. Steam Engineering.

Dynamo Room and Testing Apparatus.

INTERIOR VIEWS OF WORKSHOPS AT THE U. S. NAVAL ACADEMY.

gineer with the rank of Commander. He has for his assistants one Chief and five Passed Assistant Engineers, and a professor of Drawing, to carry on the work of instruction in the two departments.

By an Act of Congress, approved July 4, 1864, authority was given to the Secretary of the Navy to establish a course of instruction for cadet engineers at the Naval Academy, the number undergoing instruction at any one time not to exceed fifty. It was not until two years later, in 1866, that any appointments were made, when two young men were admitted. With these, and two admitted the folowing year, the cadet engineer system at the Naval Academy had its beginning. Of the four so admitted, one remains in the service to-day, and is Chief Engineer of the Naval Station at Havana.

In 1866, a class of sixteen Acting Third Assistant Engineers was ordered to the Naval Academy to pursue a two years' course of instruction, and these were graduated in 1868.

The education of engineer officers at the Naval Academy met with considerable opposition, and it was not until 1871 that the system of admitting each year a number of cadets to study engineering subjects to fit themselves for the duties of engineer officers in the navy can be considered as having been regularly established. In that year a class numbering sixteen was admitted, the appointments being made after competitive examination. This class, and the classes admitted in 1872 and 1873, pursued a course lasting two years, and were then graduated. After performing from one to two years' sea service in cruising naval vessels the members were commissioned as Assistant Engineers.

In 1874, the course at the Academy was extended by Congress to four years, this applying to the class entering in September of that year; this was the first *fourth* class of cadet engineers to become a part of the battalion of midshipmen, as it was then called. The appointments were made after competitive examination, the subjects of examination stated in the circular being the following: "Arithmetic, Algebra through equations of the first degree, Plane Geometry, Rudimentary Natural Philosophy, Reading, Writing, Spelling, English Grammar, English Composition, Geography, Freehand Drawing and an elementary knowledge of the principles governing the action of the steam engine." It was also specified that "other qualifications being equal, those possessing the greatest skill and experience in the practical knowledge of machinery will have precedence for admission."

The cadet engineer system being now well established, candidates in increasing numbers appeared each year, until finally there were as many as two hundred and fifty competitors for the twenty-five appointments. The examination, although apparently easy from a superficial view, was, in fact, made by the Academic Board sufficiently searching on the subjects specified. In fact, this system of selection was such as to insure that the young men selected were the scholars. Classes of twenty-five were admitted each year, the course was well worked out and improved, until with the fine material at its disposal, it became at the time when it was abolished, a school of marine engineering not excelled by any. The Act of Congress of August 5, 1882, making extensive reductions in the navy, swept the marine engineering course out of existence. To show that the school had been successful in the results sought to be obtained, it is only necessary to refer to the prominent part taken by its graduates in the designing, building and management of the machinery of our new naval vessels; or to the high positions taken in the engineering world by those wno, wearied by their long wait for promotion, have resigned.

The present course was established by special act approved March 2, 1889, in which it is provided: "That the Academic Board of the Naval Academy shall on or before the thirtieth day of September in each year, separate the first class of naval cadets then commencing their fourth year into two divisions, as they may have shown special aptitude for the duties of the respective corps, . . . and the cadets so assigned to the engineer corps division, of the first class, shall thereafter pursue a separate course of study arranged to fit them for service in the engineer corps of the navy."

It is seen from the provisions of the preceding act that for three years all cadets being educated at the Academy pursue precisely the same course of study, and that it is only during the last year that any separation is made. It might be supposed that, consequently, engineering education was limited to this one year's course of instruction; such, however, is far from being the case, as, in fact, instruction in engineering, or its kindred subjects, extends throughout three years of the course.

A short digression here as to the division of time is pertinent.

The Academic year, extending from October to June, is divided into two terms of four academic months each. The day is divided into three study periods of two hours each, one hour of the two being devoted to study, and the other to recitation in the different branches, so that there are in one week sixteen (one on Saturday morning) such periods. Following this there is a drill period of one hour and a half, which is devoted to drills and practical work of different kinds.

During the third class year an average of three periods a week of two hours each throughout the year is devoted to mechanical drawing, and during the second class year two periods a week during the first term are thus employed.

When the cadets become second classmen their text book work in steam engineering begins; during the first term three periods each week are given to the study of mechanism—Goodeve's Elements of Mechanism, with accompanying notes and problems, by Passed Engineer Gow, being the text books used. The study of mechanism being completed, the beginning of the second term finds the class commencing the study of Marine Engines, three periods a week being devoted to the subject, and that most excellent work, the Marine Steam Engine, by Sennett and Oram, with notes, problems and additions to conform to United States naval practice, are used as the text books.

At the end of the annual examination in June of each year the assignment to the engineer division

NAVAL CADETS AT WORK IN MECHANICAL DRAWING CLASS AT THE U. S. NAVAL ACADEMY, ANNAPOLIS, MD.

is made, and, after a practice cruise lasting three months, the last year of the course is commenced.

A glance at the material available for assignment will be of interest. The collegiate work preliminary to the professional course has been finished during the preceding three years, and during that time a constant weeding out process has been in operation, so that of the ninety or one hundred who started as fourth classmen about forty-five to fifty will have been left. Those who proceed have their methods of thought and study so well developed that they can grasp and digest an immense amount of matter in a comparatively short time, from twenty to twenty-five octavo pages being the usual lesson in each of the three subjects for the day.

The methods pursued, coupled with the fact that future promotion, as regards classmates, depends on the standing taken at the end of the course, furnish the strongest incentives to doing the maximum of work. The sections assigned to each instructor are small, ten at the most, with the average about eight, and each cadet receives a considerable amount of the instructor's attention. The standing rule in many of the departments is to keep the cadets employed throughout the entire recitation hour. Marks are assigned for each recitation; examinations are held monthly, semi-annually and annually. Daily, weekly and monthly marks are combined in a certain definite manner, and those who do not receive 62.5 per cent of the maximum for their final mark are considered as unsatisfactory and are required to resign. From the preceding it is seen that the material from which the first class is formed is well and thoroughly sifted.

The assignment of time in the first class year gives ten periods a week to steam engineering, three to mechanics and strength of materials, and three to electricity, light and heat during the first term. The second term's assignment is eleven periods to steam engineering and four to naval construction and shipbuilding; the remaining periods are devoted to hygiene and naval law.

The time assigned to steam engineering is divided among the following branches: Marine engines, boilers, designing machinery and experimental engineering, and in each branch, although text books are used, a vast amount of additional matter is given the cadets by means of notes published in pamphlet form, each cadet being provided with a copy.

A statement more in detail of the items in each branch will be necessary for a proper understanding of the course. Some of the items in the branch "Marine Engines" are as follows: Horse power, nominal and indicated, and the efficiency of the engine; resistance of ships and the horse power necessary for speed; space occupied and general description of modern marine machinery; engines, simple, compound and triple-expansion; expansion of steam, mean pressure, etc.; piston speed, stroke of piston, revolutions, size of cylinder; cylinder fittings; the piston, piston rod, connecting rod; shafting, crank, line and propeller shafts; foundations, bed plates, columns, guides and framing; the condenser and its necessary pumps; valves, valve gears and valve diagrams; propellers, sea cocks and valves; erecting machinery on board ship; starting and reversing of main engines; materials used by the marine engineer.

These are studied, with Seaton's Manual of Marine Engineering as a text book, supplemented by lectures, notes, and oral instruction as is needed to make the cadets thoroughly acquainted with the latest American marine engineering practice.

A short course on metals and alloys is given, using as a text book Metals, by Huntington and McMillan; also a course in Thermodynamics, with Cotterill's Steam Engine as the text book, supplemented by notes, and a short course covering the practical operations of casting and founding, smithing and forging, boiler making and plate work, and laying off machine work is given, using Lineham's Mechanical Engineering, Part I, as the text book.

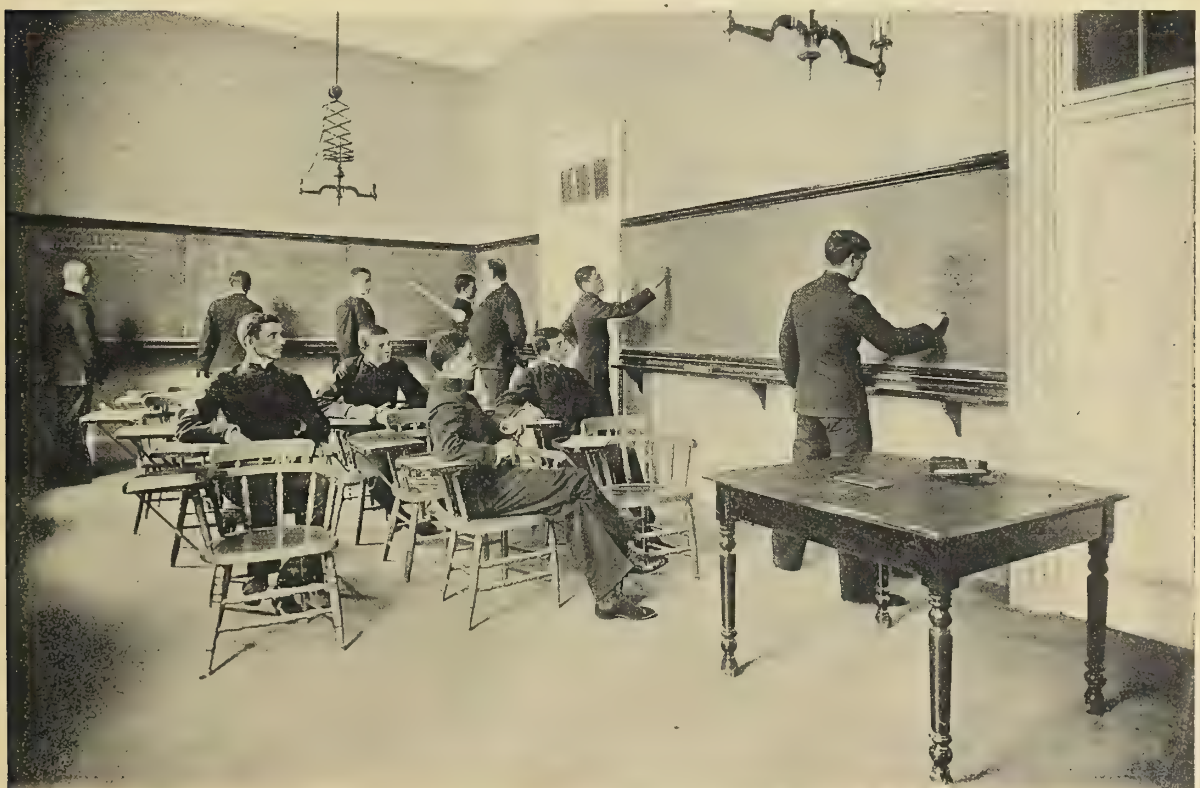
These courses are all embraced under the head "Marine Engines," to which three periods a week throughout the year are assigned.

The course in "Boilers" extends throughout the year. The first term is devoted to a practical study of the different types of boilers, both for land and marine purposes, with special attention to the types, both cylindrical and water tubular, specially adapted for use at sea; the different fuels used, boiler mountings and details, the arrangement of different units to obtain the necessary power, the wear and tear, and the methods of making the necessary repairs. The aim being to give the cadet a thorough knowledge of the marine boiler, in its entirety and all its details, as well as a good idea of the proper methods of management to insure economical working and freedom from accident and extensive repairs. Stromeyer's Marine Boiler Management and Construction forms the ground work from which this portion of the course is built up, which has two periods a week during the first term devoted to it.

Having become thoroughly familiar with the foregoing, the next step in the course is the practical design of a boiler or set of boilers, and a sample problem is as follows: "Required, a set of boilers to supply steam of 160 lb. pressure to triple-expansion engines, such as are used in a modern naval vessel of the cruiser class; the boilers not to be under an air pressure in excess of one inch of water; the engines to develop 16,000 I. H. P. as an average for four hours. The space available in the ship for boilers, fire rooms, feed pumps, etc., is 102 ft. long, 40 ft. wide, and 20 ft. high."

For working out this problem, a pamphlet, embodying the latest American practice, has been written by instructors at the Academy, and in it all of the calculations necessary for a set of boilers are made in every detail. The cadets also have access to blue prints showing the latest practice of the Bureau of Steam Engineering of the Navy Department, and from the data thus obtainable work out, under the instructor's supervision, the boiler design for the required case, deciding on the type, number and size of boilers, making the necessary provision for easy firing, fixing the sizes and dimensions of all the different parts, including details of all riveted joints. Such a drawing, for instance, shows one of five double-ended boilers, which, with two single-ended boilers of the same diam-

CADETS AT WORK IN DESIGNING ROOM—DEPT. STEAM ENGINEERING.



SECTION ROOM—NAVAL CADETS AT RECITATION.

eter, make up the set. Detail sheets showing the details of riveting, the methods of fitting ordinary and stay tubes, the sizes and shapes of the different shell and combustion chamber sheets, and of other parts requiring special delineation are also gotten out.

In "Designing Machinery" Unwin's Machine Design is used as a text book, supplemented by numerous pamphlets on designing problems, among which may be mentioned notes on design of screw propellers, connecting rods, crank and line shafts, powering ships, condensers and air pumps, and the general design of triple-expansion marine engines complete. In each case a problem embodying one of the above-mentioned subjects has been worked out in detail, showing the method of procedure for the guidance of the cadet. With regard to these pamphlets, it was early appreciated that no set of text books, with reasonable numbers, could be found that would give everything wanted for the course, and the necessity for additional material was apparent from the beginning. The question then arose as to the advisability of teaching by lectures this additional matter. This method was given a trial, but was found to take up a great deal of the cadet's time, both in attending the lectures and writing up the notes afterward; time that, in the opinion of those in charge, could be spent to much better advantage in actual work, so that the system of preparing the lecture material in the shape of pamphlets was tried and found to be thoroughly satisfactory. These pamphlets are reproduced on the mimeograph, and kept up to date by adding each year the necessary additional matter. This, of course, entails a great deal of work on the instructors, but the results show that the labor is well bestowed.

During the year each cadet gets out finished working drawings, tracings, or blue prints of the following: (1) Preliminary sheet to familiarize himself with the use of formulæ, containing the design of a knuckle joint for a boiler brace, a screw jack of certain lift and power, and a connecting-rod end with crank pin brasses, using the strap, gib and key connection. (2) Design of a steel connecting rod, with crank pin and crosshead brasses complete for a high power triple-expansion marine engine. (3) Design of a screw propeller for engines of a given power and to insure a certain required speed for a given ship. (4) General design, elevation and plan of twin screw triple-expansion engines to propel a given ship at a certain required speed. In addition some of the more rapid workers are able to get out designs for the condenser, or construct the necessary valve diagrams, and make detail drawings of the valves and valve gear. In connection with this work the cadets are required to keep note books in which all calculations and data are neatly entered. Five periods the first term and two the second, each, a week, are given to this branch.

The course in "Experimental Engineering" has three study periods a week assigned to it during the second term of four months. Two of these are given to recitations and work in the section room, with Carpenter's Experimental Engineering as a text book, and the third is given to practical work in the engineering laboratory. Following are a few of the numerous tests and experiments that the cadets are required to make, viz.: Tensile tests and the determination of the elastic limits of the different materials of construction used by the marine engineer; calorimetric measurements of the moisture in steam; friction tests of lubricants, tests of steam pumps, steam boiler tests, analyses of chimney gases, calorimetric tests of the heating power of different fuels, engine tests by Prony brake and transmitting dynomometer, setting steam valves, taking indicator diagrams, standardizing indicator springs, testing steam pressure gauges, calibrating different instruments, use of the slide rule and dynamometric tests of propellers.

There is used for testing purposes a triple-expansion engine of 100 I. H. P., here illustrated, which was built in the machine shop of the Academy by the cadets as part of the course of practical instruction. This engine drives a propeller in a tank and is fitted with indicator motion, transmitting and thrust dynamometers, thus furnishing the means of separating the different elements which go to make up the efficiency of the complete marine engine and propeller in their latest forms.

There is an Allen Dense Air Ice Machine installed in the department, and the cadets run it for a certain period, getting experience in handling the plant that may fall to their care on board ship.

The preceding is a brief outline of what may be called the "theoretical" portion of the course of instruction. In addition there is quite an extended course of practical instruction in steam engineering. This practical instruction begins during the third class year, and continues at intervals until the end of the course. In the last year the drill period, one and a half hours each day, are devoted to it. The cadets have practical instruction, and are required to do actual work in pattern-making, smithing, founding, casting and work in the machine shop, at all machine tools, and undergo a special course with hammer, chisel and file at the vise bench; enough pipe-fitting is also required to familiarize the cadet with all of the different fittings used. In the vise bench work a modification of the "Russian" system has been used with excellent results.

In the machine shop a fixed preliminary course is pursued by each cadet, consisting in executing to drawings, parallel and taper turning, cutting single and double threads, right and left handed, boring, chasing internal threads, finishing and polishing. After completing this preliminary course each cadet works on the component parts of an engine, one or more of which are always in process of construction in the machine shop. A number of vertical compound and triple-expansion engines, some of them indicating 100 horse power, have been built by the cadets and put in use in the naval service.

In the pattern shop, after the necessary preliminary course to familiarize himself with the different tools, the cadet makes a pattern of some piece of machinery, not too complicated. Then, in the foundry, from this pattern, he makes the mould and casts the piece and, should machining be necessary, finishes it in the machine shop.

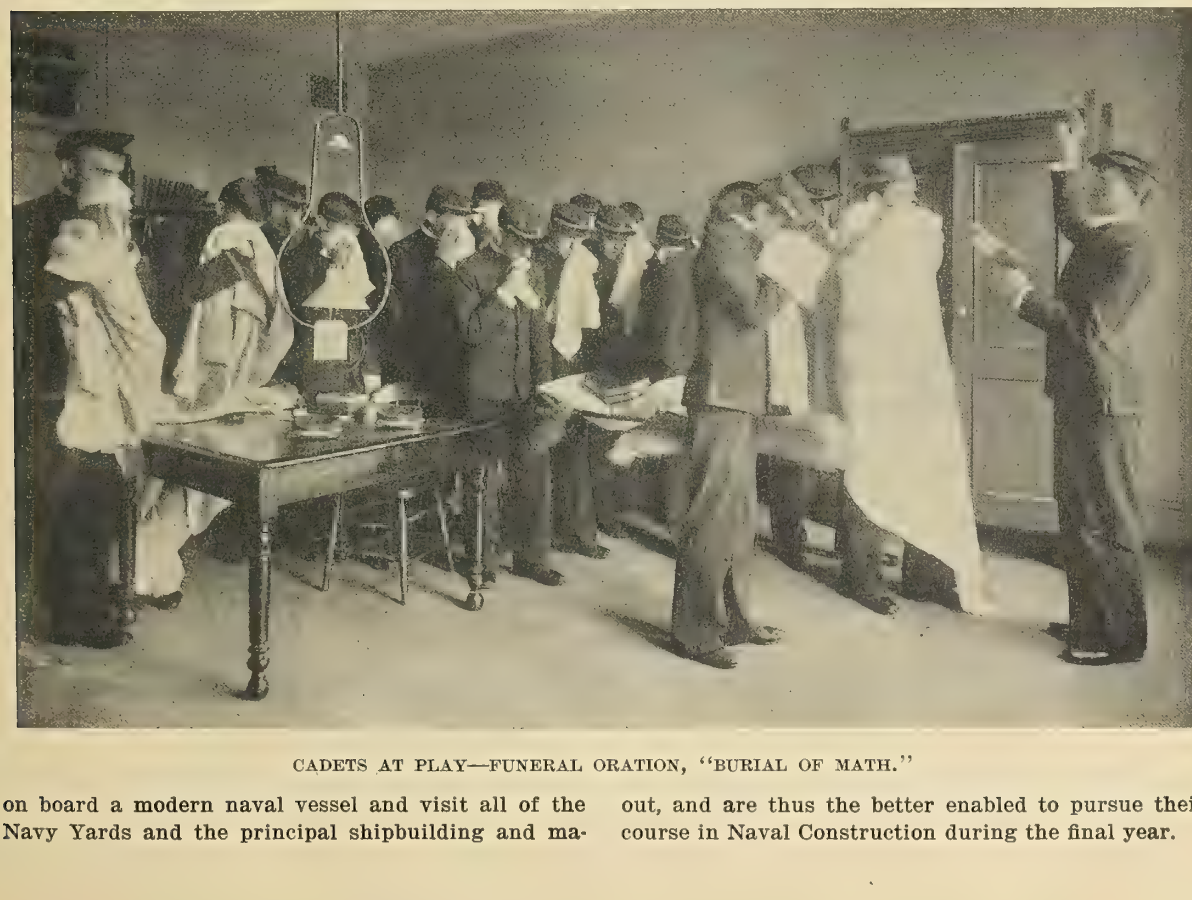
In the blacksmith shop the practical work embraces welding, iron and steel; making simple forgings, annealing, tempering, case hardening, and bending and quenching tests of metals.

In the boiler shop, riveting, soft and hard patching, caulking and tube expanding are subjects for practical instruction.

CADETS AT WORK—"SCALING THE WALL"—INFANTRY DRILL.

In all cases the cadet is required to work from working drawings, and the necessity for accuracy as to detail of finished work is thoroughly impressed.

Under the head of practical instruction comes the practice cruise, during which the cadets are embarked on board a modern naval vessel and visit all of the Navy Yards and the principal shipbuilding and marine engineering establishments along our eastern coast. This cruise lasts three months, from June to September, and is most valuable as a means of acquiring information on practical professional subjects. The cadets in charge of an instructor visit the different shops, and see the processes of construction of the component parts of modern marine engines and boilers, their incorporation into the whole, and the different stages of the erection of the machinery on board ship. They also see shipbuilding processes carried out, and are thus the better enabled to pursue their course in Naval Construction during the final year.



CADETS AT PLAY—FUNERAL ORATION, "BURIAL OF MATH."

Occasion is taken to visit and inspect steel making plants near the coast, such as the work at Sparrow's Point, or the Bethlehem Works, at South Bethlehem. Establishments engaged in any novel work of special interest to the marine engineer, such as the manufacture of corrugated furnace flues, are sure to be visited when within available distance of the coast.

That the cadets see understandingly is insured by the requirement to keep a journal in which full descriptions of everything that is of interest must be written up. Sketch books, in which to illustrate novel parts of machinery, or special manufacturing processes by means of drawings, are also required. These journals and sketch books are carefully inspected by the instructor, and any errors that may have been made are noted for correction by the cadet.

The practice cruise is also used as a means of instruction in the duties which the cadets will have to perform on board ship after graduation, both at sea and in port. While the practice steamer is making passage from port to port they stand regular watch with the engineer division, and so perform the different duties which fall to the enlisted force of the engineer department of the cruising naval vessel. They do a certain amount of firing, stand watch as watertender, oiler, and machinist-in-charge. This gives them a valuable amount of experience in the management of boilers, main and auxiliary engines while under way, as well as in getting up steam and coming to anchor.

Apropos of this practical instruction is an incident of the memorable cruise of the battleship Oregon from the Pacific to our eastern coast (a cruise unparalleled in naval annals, and which reached its climax in the running fight off Santiago, when the fifteen-knot battleship overhauled the twenty-knot Italian built cruiser), related to the writer by Chief Engineer Milligan, U. S. N. He spoke of the enthusiasm of all in his department, and of the hearty co-operation alike of officers and men; how the firemen just off watch would again hasten below at any and every call for increased speed. Mentioning one of his Assistants, who, while at the Academy was one of the best football players, and so blessed with an excellent physique, he said: "You remember R—— of course. Several times when he was on watch we were trying to make speed, and some of the firemen began to play out. He would then take shovel, hoe and slice bar, and work the fires himself, and by his encouraging example nerve the men to renewed efforts." Although the ability to do firemen's duties may not be an essential part of the naval engineer's professional attainments, the ability to do one or many of the numerous jobs on board ship requiring mechanical or trained skill is of decided advantage, and the constant aim of the instruction at the Naval Academy is to have, with reasonable limitations, the trained hand accompany the educated brain.

After four years of study at the Naval Academy the cadets are graduated and sent to sea in cruising ships of the navy for a period of two years. During this cruise, which by law is a part of the course, they obtain the necessary practical experience in the management and care of the machinery to fit them for their future duties as Assistant Engineers in the navy. Owing to the small number in the grade of Assistant Engineer the graduate cadets have been, within a short time after graduation, called on to perform the regular duties usually assigned to Assistant Engineers. The efficient manner in which they have performed all of these duties speaks well for the course of preparation at the Naval Academy.

The scope of this article allows only a mere outline of the course in the other Academic Departments, which include—*Mathematics:* Algebra, Geometry, Descriptive Geometry, Trigonometry, Plane and Spherical; Analytical Geometry, Stereographic Projections and Solutions of the Astronomical Triangle. *English:* English Grammar, Outline History of the World, History of the United States and of the United

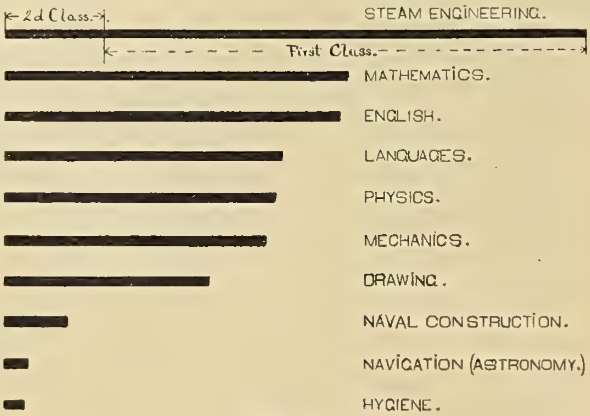


FIG. A.

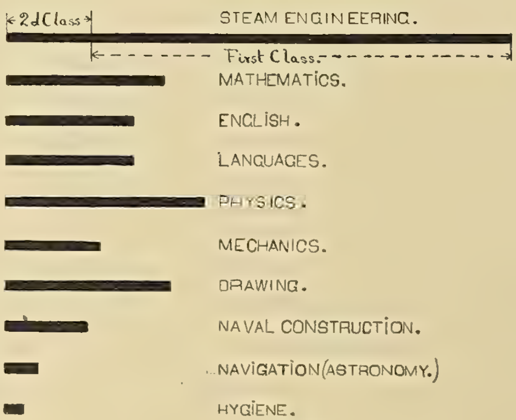


FIG. B.

States Navy, Rhetoric, Composition, the Constitution of the United States, and International and Military and Naval Law. *Languages:* French and Spanish. *Physics:* Elementary Physics, Chemistry and Qualitative Analysis, Light and Heat, Electricity and Magnetism, Physical and Electrical Measurements. *Mechanics:* Differential Calculus, Integral Calculus, Mechanics, Applied Mechanics, Method of Least Squares. *Drawing:* Mechanical and Descriptive Geometry Drawing, Sketching from Models, Making Tracings and Blue Prints. In the Department of Physics, the course in *Electricity* is given, which contains a large amount of practical work, including the running, testing, and management of dynamos.

That the educational standard maintained throughout is a high one is shown by the high rank taken by those graduates who, having been detailed for study abroad, have taken courses in Naval Architecture and Engineering at the best schools of Great Britain and France, where, although thrown into competition with men of greater age, they have either led their classes or stood well up towards the top. The accompanying diagrams, figures *A* and *B*, show, relatively for the entire course, (*A*) the time devoted to recitation in the different departments, and (*B*) the weights given to the multiples for determining the final standing of the different cadets at graduation.

From present indications, before this article appears in print, the Navy Personnel Bill will be enacted into law, the engineer division of cadets at the Naval Academy will be a thing of the past, and in future all cadets will have the same course in engineering. What the course for the "fighting engineer" of the future is to be has not been, perhaps, entirely thought out, but that it may be a development on the lines of the present one to meet the new requirements of the naval service is most certainly to be desired.

Torpedo-Boat Destroyer Ventilators.

Our engraving shows the method of making torpedo-boat ventilators adopted at the Maryland Steel Company's yard at Sparrow's Point, Md. These ventilators are made of copper, and when finished are 4 ft. high, 13 in. dia., with elliptical mouth, 22 in. by 29 in., and as they are made from one sheet of copper they have only one brazed seam. To the right of the figure one of the shapes is shown, and on the truck two completed ventilators. The weight and cost of these ventilators are as follows:

Weight of plate for ventilator before cutting	57.44 lb.
Weight of plate after corners are cut	50.90 lb.

COST OF FIRST DOZEN.	
57 1-2 lb. copper at 16c	$ 9.20
Labor for one ventilator	18.50
Complete	$27.70 each

COST OF SECOND DOZEN.	
Copper at 16c. per lb	$ 9.20
Labor for one ventilator	14.66
Complete	$23.86 each

VENTILATORS MADE IN ONE PIECE—BEFORE AND AFTER.

The American-Hawaiian Steam Navigation Co. has been incorporated under the laws of New Jersey, with an authorized capital stock of $750,000, for the declared purpose of operating a line of steamships between the United States and the Hawaiian Islands. The incorporators include G. S. Dearborn, W. B. Flint and James H. Post, of New York, and O. T. Sewall, of San Francisco, Cal.

By making a ventilator out of one sheet instead of two a saving of metal of 9.33 lb. is effected, which represents about $1.50, and the labor saved is about $3.00, or a total of $4.50 for each. The ventilator is made out of No. 16 B. W. G. sheet. Those illustrated are part of the coppersmith's order at this yard for the U. S. torpedo-boat destroyers *Truxtun*, *Whipple* and *Worden*, now building by the Maryland Steel Company.

TORPEDO BOAT DESTROYERS FOR SEA SERVICE, WITH SPECIAL REFERENCE TO PACIFIC COAST CONDITIONS.*

BY G. W. DICKIE.

Important naval events are occurring in such rapid succession, modifying opinions that we had maintained as perfectly sound, and forcing others to be abandoned that we had considered as firmly established, that any attempt to produce a paper on the subject I have been requested to write upon may fail to express the opinions of the author when it comes to be presented before the Society. In fact, this is the third attempt (begun on the first of August) to put in presentable shape the conclusions arrived at in regard to the chief characteristics required in a design of a torpedo boat destroyer that would meet all the conditions of service on the Pacific coast.

On the first page of a paper that I have just laid aside as not expressing the opinions I now hold, I find the following, that expresses the difficulty of presenting this subject:

"I feel at the present date (April 25, 1898) that I am running some risk of losing any little reputation that I may now possess by the expression of opinions that the stern facts of actual service in war may prove to be entirely wrong. Still, I desire, if possible, to complete this paper before anything happens that would in any way modify the opinions I now hold in regard to the utility of the latest developments in the construction of the type of vessel known as the torpedo boat destroyer."

More events have taken place since the above was written than usually occur in three months of naval history. In fact, these three months have provided material enough for naval architects, marine engineers and ordnance experts to form opinions from for years to come. It takes time, however, to form opinions, and more time to give them anything like practical form, and still more time to test the material forms into which these opinions finally shape themselves. The opinions expressed in this paper have not been entirely formed from the naval events of the past three months, although some of them have been modified by these events.

The conditions of service are not altogether those that war produce. A seaworthy vessel must possess many and varied qualities apart from those belonging to the special service in which the vessel is engaged. A vessel built with the special object in view of carrying large cargoes at a low rate of speed and a low rate of freight must have, besides the capacity to carry, the ability to safely meet the storm conditions of the ocean on which she and her cargo are borne. A fast passenger steamship, built with the special object in view of obtaining the greatest possible speed within the paying limits of the service, must still conform to the stern requirements that the ocean imposes on all those who "go down to the sea in ships and do business in the great waters."

A torpedo boat destroyer must possess other qualities than those necessary for the destruction of torpedo boats. In fact, the destroyer must be a seagoing vessel, able to remain at sea with the fleet to which she is attached or to make independent voyages.

The torpedo boat is intended, if the writer understands the purpose for which such craft are designed, as a part of harbor or coast defence, to be kept under shelter until a chance occurs for her to dart out, under cover of night or fog, and attempt to sink a hostile vessel or vessels. Her work is, therefore, short and sharp, requiring a supreme effort, well directed and of short duration.

The work of the torpedo boat destroyer is to prevent the torpedo boat attack, and is, therefore, performed in open water. She must keep the sea with the attacking fleet, watching every place of refuge for a torpedo boat. She must, therefore, possess speed equal to that of the torpedo boat; a battery powerful enough to destroy her; seagoing qualities to enable her to keep a watch in spite of weather. She should be able to cover long distances at a high rate of speed and in stormy weather. The fleet to which she is attached should not be delayed and hampered by guarding her from harm; she ought, instead, to be able in all kinds of weather to act as a scout in advance of the fleet, keeping the larger vessels informed as to the whereabouts of a possible enemy. Such would be an ideal torpedo boat destroyer.

It cannot be said that the present type of torpedo boat destroyer comes near meeting these requirements. Quite a large number of destroyers now meet the requirements, in the matter of speed, if required for a short time only, in smooth water, and if she is in good order; but the one quality of speed has been made paramount to all other qualities to such an extent that the full speed can only be reached when the conditions are such that the seagoing qualities can be neglected.

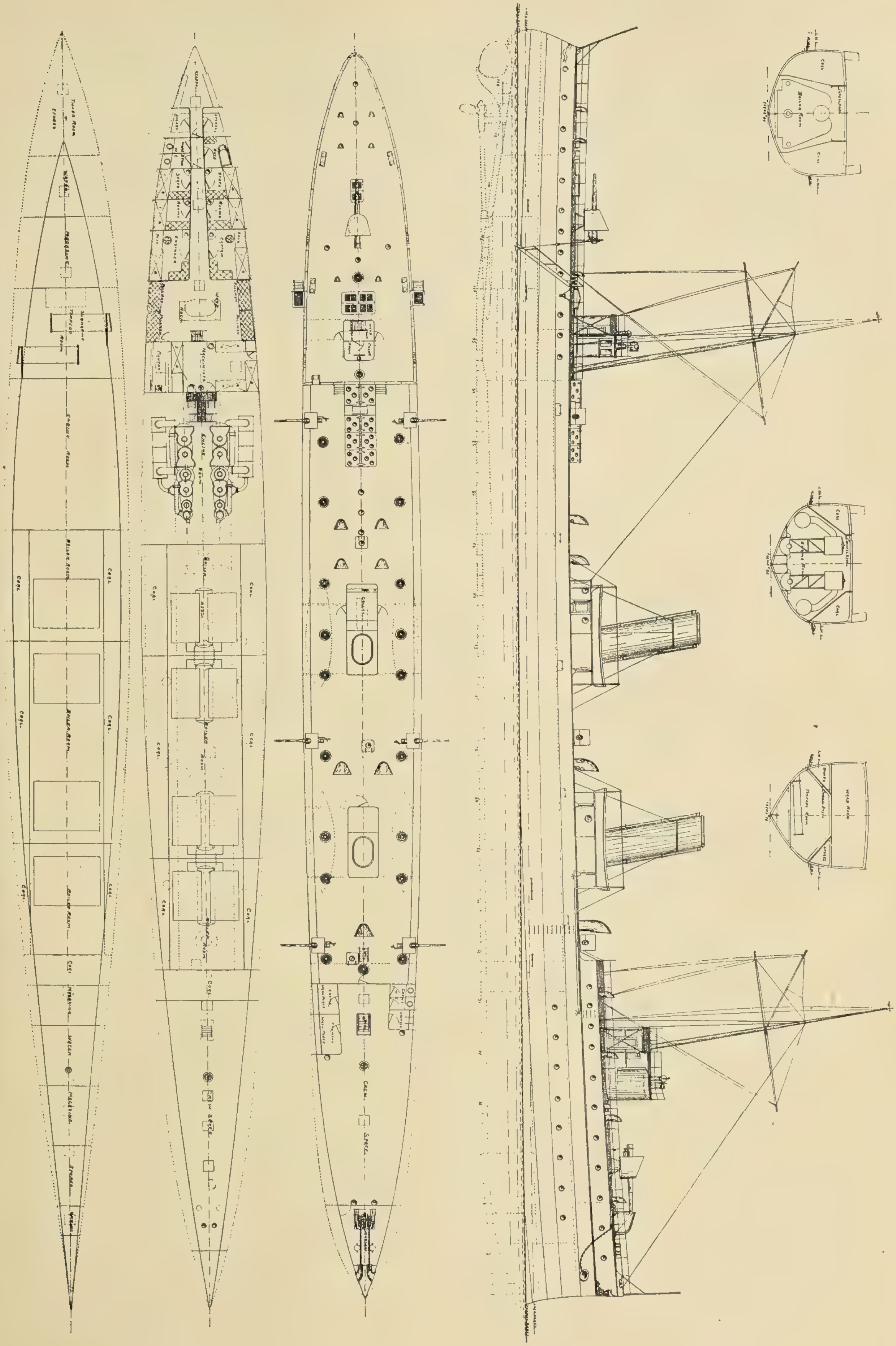
It is because we think that the most important qualities required in a seagoing vessel are deliberately neglected in the fastest torpedo boat destroyers, and which we feel renders such vessels entirely unfitted for service on the Pacific coast, that we have mustered courage enough to state, as plainly as we can in words, the deliberate opinions we have formed on this subject.

While the conditions of service for such a vessel on the Pacific coast are not different in kind from those that prevail on the Atlantic seaboard of this country, the adverse conditions are far greater on the Pacific.

The great distance between harbors on the Pacific coast and the almost universal condition of rough water along the coast from Point Conception in the south to Cape Flattery on the north, with only one place of refuge, renders it necessary that any vessel for practical service outside the harbor of San Francisco or the smooth water of Puget Sound must have good seagoing qualities and be able to remain outside in all conditions of weather.

The qualities necessary for this service are not possessed in any degree by the present type of torpedo boat destroyer. While they have made voyages of considerable length at sea, they have done so usually

* Read at the Sixth General Meeting of the Society of Naval Architects and Marine Engineers. For discussion see December, 1898, issue of Marine Engineering.



SKETCHES OF PROPOSED 800-TON TORPEDO-BOAT DESTROYER, MADE BY G. W. DICKIE, SAN FRANCISCO, CAL.

under the care of a larger vessel. They have needed extra care, both in watching the weather, taking advantage of every shelter that lies in the way, and if the destination is reached without mishap, it is something to be proud of, as being entirely outside of the service for which the vessel is fitted.

Now, such a vessel in commission on the Pacific coast cannot go from San Francisco harbor to any other harbor without making an ocean voyage of several hundred miles, with a probability of encountering rough weather.

The disastrous results of many late attempts to steam or tow light craft to Alaskan waters, most of them better able to stand rough water than the fastest type of torpedo boat destroyers, show the necessity of substantial seagoing vessels for service on this coast.

The 420-ton destroyers lately ordered by our Government are a decided improvement in this class of vessel, but we do not think they are fitted even yet to meet the special conditions of service on the Pacific.

The annexation of the Hawaiian Islands requires a much greater radius of action for such a vessel, and, we think, a different treatment. In fact, we maintain that if thirty knots or over is aimed at as the supreme speed, a sufficiently staunch seagoing vessel cannot be produced in the present state of the art, and that the present so-called thirty-knot torpedo boat destroyers have not, in fact, the speed with which they are credited as being available when required.

The supreme efforts required, under expert management and with special trial trip crews, to reach the contract requirements are seldom or never repeated in the life of the boats.

If these boats and their machinery were made more substantial, so that their full power could be exerted at any time and without risk, and the hull stand a moderate sea without danger, the thirty knot boat, by reason of the extra displacement, would drop to about twenty-seven knots; yet we venture to assert that such a boat, ordered to reach a point at sea, say 100 miles distant, in the shortest possible time, would reach the objective point in less time than the regulation thirty knot boat that is said to get a horse power in fifty pounds weight of machinery. A large proportion of naval vessels rated at high speeds, especially those over twenty knots, have obtained such speeds under conditions that cannot be reproduced when the speed is most needed, and a good, reliable, heavy engined, sixteen or seventeen knot boat may outstrip them in a fight.

Whatever speed a fighting ship has ought to be produced when ordered from the bridge. An Atlantic liner would not be considered a success if in ordinary weather she could not cross the ocean at very near her trial speed, and if the machinery of a naval ship were as substantially built she could do the same if necessary as long as her coal held out. Merchant ships are now making the longest possible sea voyages with a steady and continuous production of steam greater than that produced per foot of grate in naval vessels in three, four, or six hours forced draught trials that are said to be so destructive to boilers.

In the merchant service machinery is built for full power as a normal condition. In the Navy full power is only to be resorted to under great necessity, and maintained at a terrible risk, hence the difference.

Returning to the subject proper of this paper, we would propose for a torpedo boat destroyer adapted for service on the Pacific coast the following general characteristics as necessary to meet the conditions of the varied service required, the outline drawings accompanying this paper being illustrations of how we would embody these qualities in a seagoing vessel:

Length on normal water line	250 ft.
Extreme width	25 ft.
Depth moulded	15 ft.
Draught of water on trial	8 ft.
Draught of water loaded	9 ft. 5 in.
Displacement on trial	640 tons.
Total load displacement	800 tons.
Indicated horse power on trial	7,000 tons.
Speed on trial	25 knots.
Radius of action, 12 knots	3,200 knots.
Best speed from San Francisco to Honolulu	15 knots.
Best speed from San Francisco to Puget Sound Naval Station, or San Diego, good weather	20 knots.

The weights provided for are as follows:

Ordnance	36 tons.
Machinery, including water in pipes and boilers, evaporating plant, tools, spare parts, water in water tanks, etc	230 tons.
Hull, complete, and fittings	300 tons.
Crew and effects, including portable furniture.	14 tons.
Coal at normal trim	60 tons.
Making the normal displacement	640 tons.
Coefficient at 8 feet draught	.448

With bunkers full of coal there would be 160 tons added, the full coal capacity being 200 tons.

As will be observed by the outboard profile (see page 25), we have designed this vessel to have a full forecastle, extending to the forward fire room, and a half poop extending to the engine room. Between the poop and forecastle a hammock berthing extends the full length.

The 6 pounder guns, of which there are six, would be carried on rail mounts above the hammock berthing. This arrangement would give very good quarters, both for officers and crew.

Casings around the two smoke pipes are carried up high enough to carry the inner ends of the boat skid beams. This enables four boats to be carried, while the casings furnish room for the galleys on deck.

We propose to carry two 4 in. rapid fire guns, one on the forecastle deck and one on the poop. The conning tower is of 1 in. nickel steel.

There is a chart house aft of the conning tower, and a bridge above. There is also an after steering house on the poop. This covers the stairs to the officers' quarters and carries the searchlight above. This light would be controlled from the forward bridge.

The machinists would occupy a space at the forward end of the poop, entering from the landing leading to the engine room, aft of which would be the ward room, and officers' staterooms. The total complement of officers and crew would be seventy-five.

We have, in this vessel, purposely omitted all deck torpedo launching tubes, believing that they should form no part of the armament of a seagoing torpedo boat destroyer; as such a vessel must be prepared to go into action along with the fleet of which it forms a part, superior speed would enable her to choose the kind of vessel with which she would engage. The deck tubes would, in such a case, if there was any intention to use it, contain a charged torpedo that would, in such an exposed position, be a constant source of dread to those on board. We have, therefore, arranged for two special submerged torpedo tubes in a protected compartment aft of the engine room. Owing to the limited width of the vessel, these tubes would be designed to open on top instead of at the inner end. We believe that there is no mechanical difficulty in designing the discharging tube and the impeller that carries the torpedo clear of the skin of the vessel before release, so as to admit of the torpedo being placed in the tube from the top side.

The sloping sides of the torpedo room would be of 1 in. nickel steel. We have also provided 1 in. nickel steel protection extending the whole length of the engine and boiler compartments, so as to give a moderate amount of protection when the coal bunkers are empty.

We have shown four Thornycroft boilers in our design, and four cylinder, triple expansion engines of 7,000 horse power. We have allowed thirty tons extra weight for the machinery above that allowed for the same horse power in the usual types of torpedo boat destroyer, so as to have a fair margin of safety in all main parts of the engines and boilers.

In this design our aim has been to produce a seagoing torpedo boat destroyer that can go to sea and remain at sea without any special risk, and at sea can maintain a speed of twenty-five knots for a few hours when such speed is required; that can make extended voyages, thus serving the purpose of a scout or dispatch boat, whenever or wherever such service is required; that carries a battery that makes her a torpedo boat destroyer in fact.

This boat would show better speed under regular service conditions than any of the so-called thirty knot torpedo boat destroyers, and for seaworthiness, habitability, or fighting capacity far outranks them.

The latest addition to the British Navy, the first-class battleship *Glory*, was floated from the building dock at Laird's yard, Birkenhead-on-the-Mersey, England, on March 11. The *Glory* is of the *Canopus* class, designed by Sir William H. White, director of naval construction. Her dimensions are: Length, 390 ft.; breadth, 74 ft.; mean draught, about 26 ft. 6 in.; displacement, 12,900 tons; freeboard forward 22 ft. 6 in., aft 19 ft.; indicated horse power, 13,500; speed, about 18 1-2 knots. The *Glory* has stowage for 2,000 tons of coal. The armor is Harveyized steel. There is a protective deck from the lower edge of the armor, covering the machinery, magazines and other vital parts. She is lighted throughout with electricity, and will be equipped with six searchlights. The armament will consist of four 12-in. 46-ton guns, mounted in barbettes in pairs and firing a projectile weighing 850 lb., with a powder charge of 148 lb. There are also forty-three rapid-firing guns and four torpedo tubes. She will have triple-expansion engines and Belleville boilers.

S.S. ATLAS—NEW OIL-TANK STEAMER FOR THE STANDARD OIL CO.

In the inset supplement with this issue the plans for the new steel oil-tank S.S. *Atlas* for the Standard Oil Company are given. This vessel, which was constructed recently at the Roach yard in Chester, Pa., is a fine example of the most modern practice in the construction of vessels carrying oil in bulk. She is a single-deck, schooner-rigged, single-screw steamship of the following dimensions: Length, 248 ft.; beam, 40 ft.; and depth, 22 ft. 6 in. Her gross tonnage is 1,942 tons, and net tonnage 1,243 tons, and with full cargo and coal on board she draws about 19 ft. 6 in. of water. She has a capacity for 720,000 gallons of oil, and is designed with large hatches so that, if need be, she can carry package freight. Her bunkers will hold about 500 tons of coal.

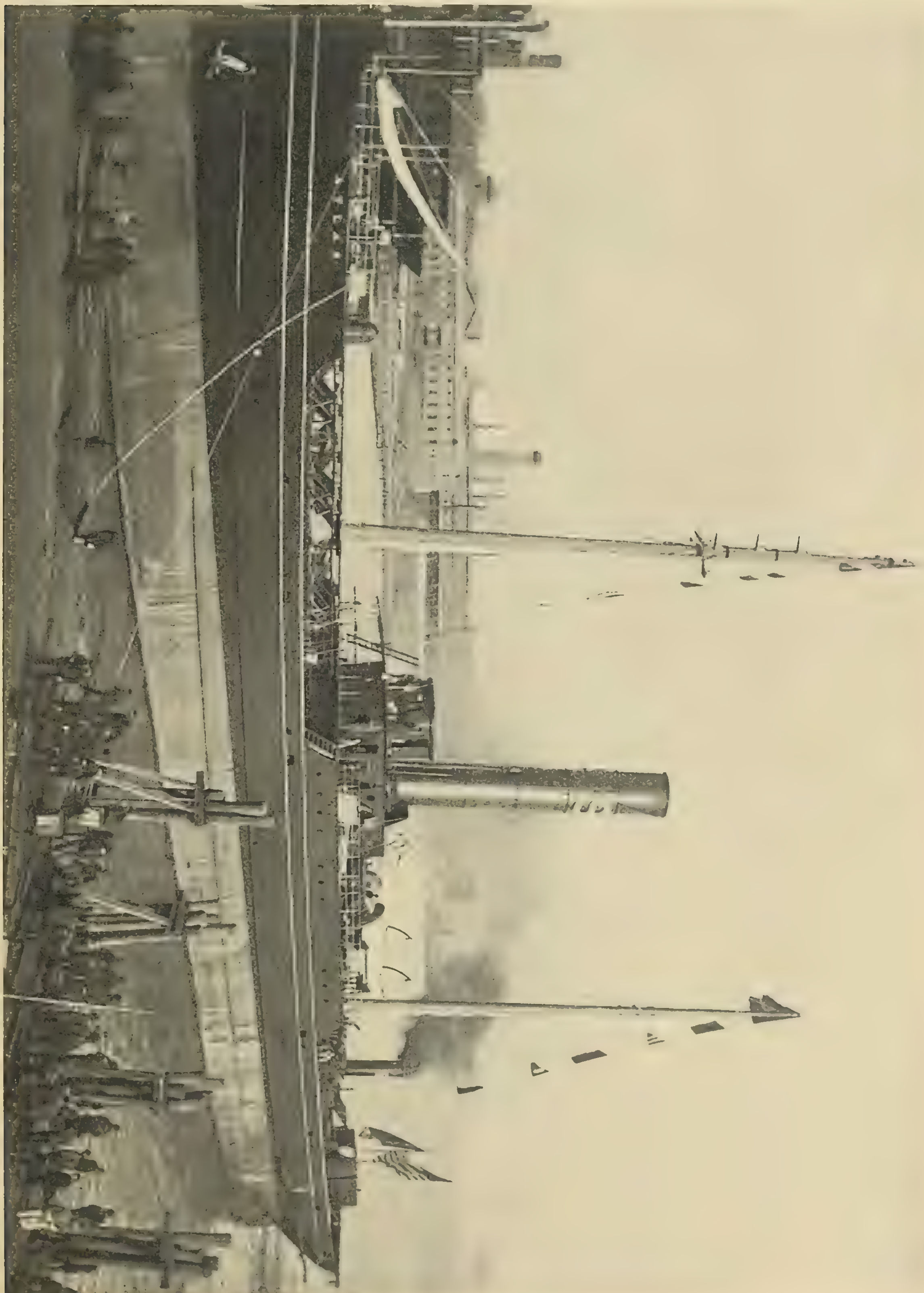
As shown by the accompanying photograph of the vessel ready for her trial, she has somewhat the appearance of an American coast liner, with a forecastle, bridge house amidships, a house aft, and a tall smokestack. She is built of open hearth mild steel to conform throughout to Lloyd's rules for oil-carrying vessels. The *Atlas* is fitted with a cellular double bottom, extending from the forward bulkhead in the bunker to the after bulkhead in the engine space, about 60 ft. amidships, and this is piped and connected so that it can be used to carry fuel oil, and similar provision is made in the forward and after peaks. There are ten transverse and one longitudinal bulkheads, all very strongly braced by vertical and horizontal girder framing to resist the pressure of the oil cargo. The frames are spaced 24 in. throughout. Those fore and aft of the double bottom are bulb angles 5 in. by 3 in. by 8-20 in., in one piece from center keelson to main stringer plate. The frames of bridge and forecastle enclosures are bulb angles 5 in. by 2 3-4 in. by 7-20 in. attached to main stringer plate by 7-20 in. brackets and angles 3 in. by 3 in. by 7-20 in. In way of the double bottom Z-bar frames are used, 5 in. by 3 1-4 in. by 3 1-4 in. by 8-20 in., attached to margin plates by 8-20 in. brackets, with double angles 3 1-2 in. by 3 1-2 in. by 8-20 in. Angle reverse frames 3 1-2 in. by 3 in. by 8-20 in. are fitted on every floor, all fore and aft, and run from the center keelson to the turn of the bilge in one piece, and double in the engine space and in way of the boiler bearers under the double bottom. The floors are 24 in. by 10-20 in. for three-fifths the length amidships and 9-20 in. and 8-20 in. at the ends, where they increase in depth in the usual manner. They are attached to the center keelson by gussets and double angles. At the ends beyond the cargo spaces they extend across in one piece, and all are bent up at the bilge. The keel is 36 in. by 15-20 in. for three-fourths the length amidships, gradually reduced to 12-20 in. at the extreme ends. It is double butt strapped and double riveted, with the keelson angles joggled over the straps. The center keelson is 60 in. by 9-20 in. through the cargo spaces, and 8-20 in. at the ends, connected to the flat plate keel by continuous angles 4 1-2 in. by 4 1-2 in. by 9-20 in., gradually reduced to 8-20 in. at the ends. There are three side keelsons on each side of the center keelson, intercostal, of 8-20 in. plate with double angles 5 in. by 3 1-2 in. by 8-20 in. on the upper edge riveted to the reverse frames and doubling clips and bracketed at the bulkheads to compensate for being cut there. The shell plating at the bottom is 10-20 in. for one-half length amidships and gradually reduced to 9-20 in. at the ends; the side plating is the same amidships and 8-20 in. at the ends. The bow plates at the load line are doubled for about 40 ft. aft of the stem, to resist ice pressure in winter. The sheer strake is 12-20 in., reduced to 9-20 in. at the extreme ends. The hold beams, in one tier, are 9 in. by 3 in. by 21 1-2 in. channel section in the oil compartments, and 9 in. by 3 in. by 9-20 in. bulb angles beyond, supported by stanchions. The steel deck plating is 6-20 in. all fore and aft, with edge seams double-riveted and butts treble-riveted. The stem is 9 in. by 2 1-2 in. hammered scrap, and the stern frame is a steel casting 9 in. by 5 in.

The bridge house enclosure amidships is built of steel about 60 ft. long and is 7 ft. 6 in. high. Forward and aft of the cargo tanks at each end there is a pump room, with a trunk passage running to the upper deck, the whole made gas tight. Coal storage is provided for in one cross bunker extending from the double bottom to the main deck, and two side bunkers in the boiler room, as shown in the drawings. The accommodations for Captain and crew are provided in the bridge enclosure and bridge deck house. The Captain's room is located in a steel house on top of the forward bridge deck; the mates' rooms on the starboard side of the bridge house. The Captain's room is finished in stamped iron sheeting insulated from the body of the house with mineral wool. It is ceiled in hardwood and fitted with berth and chest of drawers, large desk, plate mirror and leather couch, and closet. The mates' rooms are similarly fitted, though in plainer style. The pilot house is of steel, finished in hardwood and containing all necessary lockers, chart table, drawers, and all instruments and modern appliances for navigation, including engine telegraphs. In the bridge enclosure the dining room is located on the starboard side forward, is finished in stamped iron sheeting, and has accommodation for ten at table. The crew's mess room on the port side is fitted with tables and stools for twelve. In this enclosure, as shown on the plan, the well-equipped galley is fitted in the forward end with passages on either side. Here also are various toilet rooms and lavatories, sailors' quarters for six, firemen's quarters for the same number, and oilers' quarters for four, fitted with iron berths and enameled washstands. The Chief Engineer's room is on the starboard side at the after end of the bridge, with door opening into the passage opposite a door in the engine trunk, so that he can go to and from the engine room without delay or exposure in bad weather. Adjoining is the room of the first and second engineers, with hardwood finishings and modern berths and toilet fittings. Between the funnel and engine trunk amidships the donkey boiler is located, with coal bin adjacent on the port side. The bridge enclosure also contains ice, refrigerating and store rooms, and in fact all the living quarters and conveniences are concentrated in it, the officers being on one side and the crew on the other. At the after end of the bridge enclosure the steering engine is fitted in a steel annex, and it can be operated from the deck overhead, where an additional steering wheel is fitted, as well as from the pilot house; the former to be used should the shafting or gear of the latter give way.

In the forecastle there is a steam windlass fitted for 1 11-16 in. chain, with capstan on top of the deck. Aft there is also a steam capstan, and in the house aft there is a steam towing engine, fitted for 2-in. steel hawser.

The propelling machinery consists of a triple-expansion engine, of about 1,400 I. H. P., with cylinders 21 in., 34 in. and 56 in. dia. and 40 in. stroke of the usual inverted type, with condenser forming part of the back frames. This has a cooling surface of 2,400 sq. ft. The back frames are cast iron, and the front wrought iron, flanged and turned. The crank shaft is built up of fluid compressed steel, and is 11 in. dia. The propeller is four-bladed, of cast iron, and is 11 ft. 6 in. dia. The main boilers are two in number, of the three-furnace single-ended Scotch type, 14 ft. 6 in. dia. and 12 ft. 9 in. long, fitted with Morison suspension furnaces of the interchangeable type, with 160 sq. ft. of grate surface, and built for a working pressure of 170 lb. per square inch. A Bloomsburg circulator with attachment from donkey boiler and feed pipes is fitted to each boiler. The donkey boiler is also of the fire-tube type, 6 ft. 6 in. dia. and 9 ft. long, and built to withstand a working pressure of 170 lb. per square inch. The auxiliaries include an independent vertical air pump, a circulating pump with bilge connections, also a Korting injector, ash ejector, feed pump, sanitary pump, fire pump, evaporator and feed heater.

A very complete piping system connects the various oil-carrying compartments with the pump rooms fore and aft already referred to, and in these rooms powerful duplex pumps are fitted for handling the cargo, with connections to all the oil tanks, sea valves and manifolds. The pumps are of such capacity as to discharge the entire cargo in about six hours. The cargo mains are 10 in. dia., one on each side, running the length of the ship forward and aft. In each oil-carrying compartment there is a 10-in. valve and also two 2 1-2-in. bell-mouth suction connections, with the main fitted with independent valves. The forward pump is connected only with the forward tanks, and the after pump with the after tanks; both are provided with sea suctions. The discharge pipes and connections of both pumps are run into one common discharge main, with connections, and are also arranged with the necessary connections for loading. There is also, in addition, an independent loading pipe with valve 6 in. dia. in each compartment, which will be used should the system connected to the pumps get out of order. The valves used are of special make, tested for oil at a pressure of 400 lb. per square inch, and designed especially to withstand the action of naphtha and salt water. All the valve rods run to the upper deck, where bridges and hand wheels are fitted for operating them. Expansion hatches are fitted on the main deck over each oil tank, about 3 ft. high, which are filled to about half height, allowing the oil



OIL TANK STEAMER ATLAS, RECENTLY BUILT FOR STANDARD OIL CO. AT ROACH YARD, CHESTER, PA.

to expand or contract with the varying temperature to which it may be exposed during a voyage.

Hoisting engines are fitted at the forward and after cargo hatches. A well space is fitted forward and aft of the machinery space, to separate the same from the oil compartments, and over each well two trunks are fitted. These are 2 ft. dia. and 1 1-2 ft. high, fitted with cast-iron-hinged covers with rubber joints and clamps. Water tank capacity for 5,000 gallons is provided.

The masts are steel, 28 in. dia. at the foot and 90 ft. above the top of the expansion trunks, and are fitted with cargo booms and all necessary gear. The blocks are of the five-roller pattern made by the Boston & Lockport Block Co. Two bower anchors of the Baldt stockless pattern, each 3,600 lb. weight, are carried; also a stream anchor of 800 lb., and one kedge of 400 lb. The chains include 210 fathoms of 1 11-16 in. stud chain cable, 75 fathoms of 1 1-16 in. close-link stream chain, all tested to Lloyd's requirements. In addition, 200 fathoms of 2-in. steel hawser for towing are supplied. Above the bridge deck in davits three boats are carried. Of these two are metallic life boats and the other a 15-ft. Captain's gig, and there is in addition a life raft in accordance with the U. S. Inspection laws. Side lights are carried on the forecastle in steel towers, and on top of the pilot house a powerful searchlight is fitted. The ship is lighted throughout by electricity, the direct-connected set having a capacity of 150 lights.

The *Atlas* has made two trips to Boston and one to Jacksonville, Fla. Her speed at sea is about 11 1-2 knots, and when towing barge No. 81, containing 900,000 gallons of oil, the speed is about 10 1-4 knots. She is now to take crude oil from Philadelphia to the oil refineries at Tampico, Mexico.

This modern tank steamer was designed by and constructed under the supervision of John Haug, Lloyd's representative in Philadelphia, Pa.

Another long steaming record has been made by the U. S. S. *Oregon*, which arrived out at Manila March 18, after steaming in round numbers 20,000 nautical miles, or a mileage equivalent to four-fifths of the distance round the world. The actual runs made by the *Oregon* on this trip are as follows:

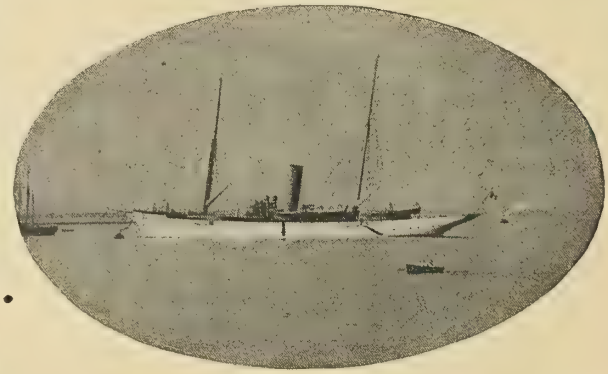
	Naut. Miles.
New York to Bahia	4,100
Bahai to Montevideo	1,717
Montevideo to Sandy Point	1,312
Sandy Point to Valparaiso	1,425
Valparaiso to Callao	1,309
Callao to Honolulu	5,147
Honolulu to Manila	5,000
New York to Manila	20,010

It is interesting to note that the *Oregon*, classed a *coast-line* battleship, completed this journey and arrived in fit condition to go straight into action, while the *Iowa*, a battleship with more freeboard, which also started from New York for Manila, was obliged to put into San Francisco for repairs, where she now is. This is the second grand performance of the *Oregon*, the first having been the famous voyage from the Pacific to the Atlantic coast during the Spanish war period, an account of which is published elsewhere in this issue.

A mishap on board the first-class British cruiser *Terrible*, 14,200 tons, was reported last month by cable. An explosion in the stockhold was said to have killed one man and seriously wounded several others. The Terrible is fitted with water-tube boilers of the Belleville type.

Sir Thomas Lipton's S. Y. Erin.

A glimpse of the magnificent steel yacht *Erin* now owned by Sir Thomas Lipton, the America's Cup challenger, is shown in the reproduction of a snap shot of the vessel taken recently in Kingstown harbor. This ocean-going vessel was built in 1897 by Scott & Co., of Greenock, Scotland, to the order of a wealthy Italian, Count Ignazio Florio, of Palermo, and originally christened the *Aegusa*. Her dimensions are: Length, 264 ft.; beam, 31 ft. 6 in.; depth, 20 ft. 6 in. Her tonnage is 1,230 tons Thames yacht measurement, and



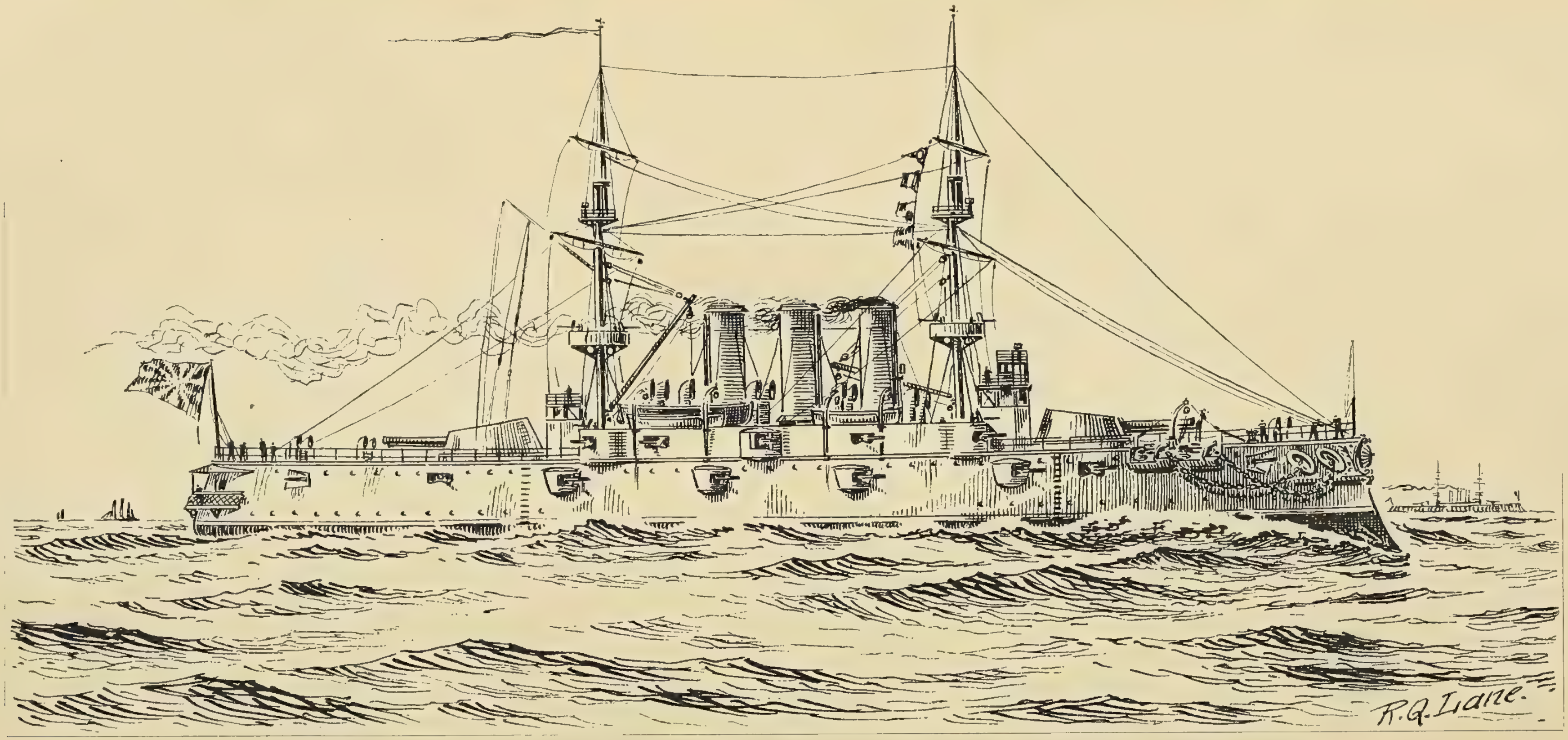
she is fitted with triple-expansion engines of 2,500 horse power and has a sea speed of 16.25 knots. She was purchased recently by Sir Thomas Lipton and renamed the *Erin*. Her present owner intends to take her to New York when he comes over to race the *Shamrock*—now being built by Thornycroft. The *Erin* will be fitted out for this voyage at Cowes. It will be remembered that shortly before the Spanish war, when the U. S. naval representatives in Europe were looking around for war and auxiliary vessels, the *Aegusa* was favorably considered, but for some reasons the negotiations were not completed before war was declared.

According to telegraphic reports, Sir Thomas Lipton will not attempt to sail the *Shamrock* across the Atlantic under her own rig, but will take her across in tow of his S. Y. *Erin*.

As figured out in Congressional Committee, the cost of the war with Spain amounted to $482,562,083.

Captain Frank Wildes, who was in command of the U. S. S. *Boston* during the fight on May 1 in Manila Bay, has returned home, his three years' service having expired, and he is now stopping in New York. He is the first of the fighting captains of Admiral Dewey's command to reach home.

Under the provisions of the new naval Personnel act an examination will be held, at some date not yet set, to fill the rank of Warrant Machinist in the Navy. There are 100 appointments to be made by competitive examination. The 400 machinists now serving in the Navy will, undoubtedly, first be given the opportunity for promotion; but should a sufficient number not be secured thus, then appointments will be made from civil life. Already a number of applications have been filed at Washington.



JAPANESE FIRST-CLASS BATTLESHIP SHIKISHIMA, UNDER CONSTRUCTION AT THE THAMES IRON WORKS, LONDON.

The pen sketch shows the new Japanese battleship Shikishima, now under completion at the Thames Iron Works, London, as she will appear steaming at sea. This vessel, which may be classed as a coast defense first-class battleship, is of great size and power. Her dimensions are: Length, 400 ft.; beam, 75 ft. 6 in.; draught, 27 ft. 3 in., and she will displace 14,855 tons. Having been designed primarily for service in home waters, her coal-carrying capacity is limited (700 tons), but the weight gained here has been used to advantage in her armor plating and batteries. She is fitted with triple-expansion engines of 14,500 I. H. P., which are expected to give her a sea speed, with forced draught, of over 18 knots. For protection she has an armor belt the full length of the water line, a belt over her central battery, a protective deck, and armored casemates and barbettes. The armament includes four 12-in. guns in the two barbettes, fourteen 6-in. rapid firers, twenty 12-pounders, and twelve 47-m.m. rapid fire guns; also five torpedo dischargers. The twin-screw engines have cylinders 34 in., 53 in. and 84 in. dia., and 48 in. stroke. She has also twenty-five Belleville water-tube boilers, with 1,140 sq. ft. grate surface and 38,000 sq. ft. heating surface, designed for a working pressure of 270 lb. per square inch. The Shikishima will carry a complement of 741, which includes an admiral and thirty-eight officers, accommodation for the latter being provided on the main deck and the crew being berthed in the forward part of the ship, mess accommodation being provided for the whole ship's company at one sitting. She will carry thirteen boats. Similar vessels are now building at Stettin, Elswick and Clydebank.

CONSIDERATION OF THE INDICATOR AND ITS USES ON BOARD SHIP—III.*

BY R. W. JACK.

Referring now to Fig. 9, it will be evident that the mean velocity of piston per degree of the crank arm's movement is equal to the difference of the versed sines of the angles of crank and connecting-rod with the line of centers. The line of centers is taken to mean the line connecting the center of shaft with the center of crosshead. The difference of the mean velocities gives the acceleration or retardation of the motion. To take a simple example, let us suppose that the piston travels at 1 in. during the first second under the action of a uniform force. At the end of the first second it has acquired a velocity of 2 in. per second, i. e., the velocity at the end of any unit of time is equal to twice the mean velocity or distance traveled per such unit. Starting from rest, we thus have an acceleration or difference of velocities at the

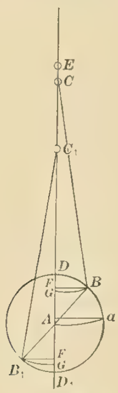


FIG. 9.

beginning and end of any interval of time of twice the mean velocity or space fallen through. At the end of the second the piston has acquired a velocity of 4 in. per second, at the end of the third second 6 in. per second, and so on, the velocity increasing directly as the time. The total distances fallen from rest at the end of each second are, respectively, 1 in., 4 in., 9 in., 16 in., etc., varying as the square of the times, and therefore the distances fallen during each consecutive second, which we take as the mean velocities, are 1 in. (4 — 1), (9 — 4), (16 — 9) = 1 in., 3 in., 5 in., 7 in., etc., showing an increase in the mean velocities, or acceleration, equal to 2 in. per second.

It is the same with the piston of an engine controlled by a crank and a connecting-rod, with this difference, that the acceleration and therefore the force required is not constant, but decreases until the piston attains its maximum velocity, that is, until the crank arm forms a right angle with the connecting-rod. This occurs at an angle of 76 deg. with the line of centers when the ratio of crank and connecting-rod is 1 : 4. At this point on the down stroke the resistance of the piston due to the acceleration of the reciprocating weights, imperceptibly changes to a positive force in the opposite direction in consequence of the retardation by the crank of the maximum velocity. If the connecting-rod were of an infinite length, or if the motion of the piston were communicated by an arrangement such as a slotted donkey crosshead, then the direction of the pressure on the crank pin would always be parallel to the line of motion of the piston, and the velocity of the piston in relation to the uniform velocity of the crank pin would increase from zero at the beginning of the stroke to a maximum at 90 deg., at which instant the velocity of the piston and crank pin are always the same. The velocity of the piston therefore varies as the sine of the angle of crank arm with line of centers. To find the force which in this case would be necessary to impart the initial acceleration to the piston, we will take a simple example, and find the force which would be required with a piston of unit weight (1 lb.), with a crank of unit length (1 ft.), moving at unit speed (1 revolution per minute). The distance that the piston would move from the dead point during the first degree of the crank's revolution is so small that we may suppose its motion to be uniformly accelerated without sensible error. So minute is this distance that it may be most conveniently taken from a table of natural sines, etc., instead of attempting its measurement by the graphic method. It will be found that the versed sine of an angle of 1 deg., when the radius is taken as unity, is .0001523, i. e., the piston has traveled this decimal of a foot during the first degree, and the time occupied at the rate of 1 revolution or 360 deg. per minute is therefore $\frac{1}{360}$th of 1 minute or 1-6 of 1 second. How does the force under which it moves compare with that which would be imparted to it by gravity, or its own weight? To answer this we must compare the distances fallen in the same time. A body falling freely from rest under the attractive force of the earth alone falls 16 ft. (approximately) during the first second. What distance, then, does it fall during the first one-sixth of a second?

$$1^2 : (\tfrac{1}{6})^2 :: 16 : x. \therefore x = (16 \times \tfrac{1}{6} \times \tfrac{1}{6}) \div 1. = \tfrac{16}{36} \text{ ft.}$$

The forces vary directly as the distance fallen during the same interval of time,

$$\therefore \frac{f}{g} = \frac{.0001523}{\frac{16}{37}} = .000341 \text{ lb. (approximately),}$$

i. e., the force required to overcome the inertia of piston, etc., weighing 1 lb., when the crank is 1 ft. long and describes 1 revolution per minute, is equal to .000341 lb. We are now enabled to construct a formula which shall embrace the varying conditions of weight, speed and length of crank. Considering only the first degree of the crank's motion, we may conceive it as acting under a uniform force, and it therefore follows that the distance fallen through by the piston varies with the length of the crank and as the square of the time. Since the rotational motion of the crank is also uniform, time may be replaced by its equivalent in revolutions of the crank, and thus, instead of the distance fallen varying as t^2, we may write it varying as N^2, because $N \alpha t$ when the speed is constant. If, then, F be taken to represent the force required to start the piston, etc. (W), from rest, with a crank L feet in length and making N revolutions per minute, then

$$F = .000341\ W\ L\ N^2$$

*From a paper read before the Institution of Engineers and Shipbuilders at Hong Kong.

and if A = the area of piston and P = the pressure per square inch, then

$$P = \frac{.000341\ W\ L\ N^2}{A}$$

Let us now apply this rule in a simple example. Suppose the piston and its appendages weighs 1,000 lb., length of stroke 2 ft., or length of crank 1 ft., making 100 revolutions per minute, and the area of piston being 300 sq. in. What is the pressure per square inch necessary to impart to the piston its initial velocity?

$$P = \frac{.000341\ W\ L\ N^2}{A} = \frac{.000341 \times 1{,}000 \times 1 \times 100 \times 100}{300}$$
$$= 11.36 \text{ lb.}$$

It would therefore become necessary in dealing with an indicator card taken from such an example under the conditions of a connecting-rod of infinite length, to deduct from the initial effective pressure 11.36 lb. in order to represent the pressure transmitted to the crank pin.

To ascertain the modification which this result must undergo in order that it may conform to the practical considerations of a connecting-rod of the usual ratio of crank, we have only to compare the distances that the piston has moved from rest during the first degree of the crank's motion. It has already been stated that with a crank 1 ft. in length, and with a connecting-rod of infinite length, the distance moved by the piston is .0001523 ft. With a connecting-rod whose ratio to crank is as 4 : 1, the distance becomes .0001904; when the length of connecting-rod is to crank as 5 : 1, the distance is .0001827. The forces required vary as the distances traveled in the same time, so that under the conditions of a connecting-rod four times the length of crank, instead of 11.36 lb. per square inch, we have, representing the initial force,

$$11.36 \times \frac{.0001904}{.0001523} = 11.36 \times 1\tfrac{1}{4} = 14.2 \text{ lb. per sq. in.}$$

Now, in order to convert an ordinary indicator diagram from a measure of work to a diagram of stresses on the crank pin, not only the distance traveled from rest by the piston is necessary, but also the relative velocities or accelerations occurring at each interval of the stroke. Stated mathematically, if x be the angle of the crank, y the angle of the connecting-rod, n the number of cranks in the connecting-rod, and d the total distance traveled by the piston from the top end of stroke in the first quadrant (an engine of the marine inverted type being observed throughout) then

$$d = \text{vers } x + (n \text{ vers } y).$$

In the second quadrant or half-stroke of the crank the distance measured from the bottom end is:

$$d_1 = \text{vers } x - (n \text{ vers } y).$$

If those distances be calculated for every degree of the crank's revolution, we are in possession of everything necessary to the object in view. The difference of the distances for each degree will give the mean velocity during that interval and the difference of the mean velocities which takes place within any two consecutive equal intervals is the acceleration acquired. It is to this result we must direct our attention, for remembering that a force varies directly as the accelerations produced, we are in a position to obtain the corresponding forces for any given position of the crank. The force required to impart the initial velocity to the piston has been found by comparing the distance traversed by the piston during the first degree of the down stroke, with the distance it would fall under a force equal to its own weight. It will be sufficient for our purpose, however, to find four points on the curve, viz., the initial force required at each end of the stroke, that point in the stroke where the piston attains its greatest velocity, and a point on either side. We will therefore take an example from actual practice, and find those points which shall enable us to convert an ordinary indicator card from one of pressures on the piston to one of actual pressures on the crank pin.

The diagram shown in Fig. 10 is taken from an engine, the diameter of whose cylinder is 17 in., length of stroke 2 ft., and the weight of piston, rods, etc., is approximately 1,200 lb., the revolutions being taken at 130 per minute. The ratio of connecting rod to crank

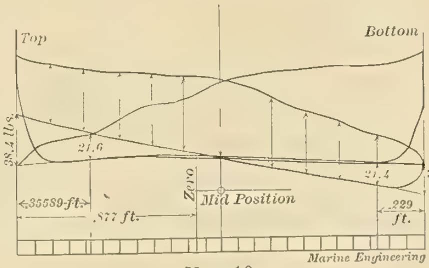


FIG. 10.

is 4:1. To find the first point, that is the initial force required to set the mass in motion from the top end, we will use the formula previously given and modify the result to compensate the error due to the angularity of the connecting rod. Let the symbols be taken as before, then

$$P = \frac{.000341\ W\ L\ N^2}{A} = \frac{.000341 \times 1200 \times 1 \times 130 \times 130}{17 \times 17 \times .7854}$$
$$= 30.5 \text{ lb. per square inch.}$$

To estimate the real pressure we must, as before, multiply this result by $\frac{.0001904}{.0001523}$, i. e., approximately 1 1-4 then, 30.5 × 1 1-4 = 38.1 lb. per square inch to be subtracted from the initial effective pressure on the piston. To find the retarding pressure at the lower extremity of the down stroke, we will again compare the distances traveled by the piston during the last degree of the stroke, and we find that during this interval the piston travels only .0001142, i. e., vers x — (4 vers y). If the connecting-rod were of infinite length, then the acceleration would simply depend on the difference of the differences of the versed sine of crank arm with the line of centers, because the angle of the connecting rod would be infinitely small and might be disregarded. Opposite positions of the crank would therefore have the same value, and the acceleration would not only be equal to the retardation, but would correspond at every point equidistant from the dead points or ends of the stroke. We see, then, that the distances traversed by the piston during the last degree toward the dead point on the bottom is with a connecting rod of the usual proportions less than that which is due to a connecting rod of infinite length. Again, the forces necessary are directly in proportion, thus,

$$.0001523 : .0001142 :: 30.5 : x,$$

therefore the force which is given out on the crank pin by the retardation of the piston is in this case

$$P = 30.5 \times \frac{.0001142}{.0001523} = 30.5 \times .749 = 22.875 \text{ lb. per square inch.}$$

To find that point on the curve at which acceleration of the piston changes to retardation, that is when the piston has attained its greatest velocity, it will be understood that this will also be a point on the back pressure line of the diagram since it affects neither acceleration nor retardation. This point is therefore at a distance from the beginning of the stroke corresponding with the position of the piston when the connecting rod makes a tangent to the crank pin circle. Fig. 11 represents the actual positions—$E\ F$ is the

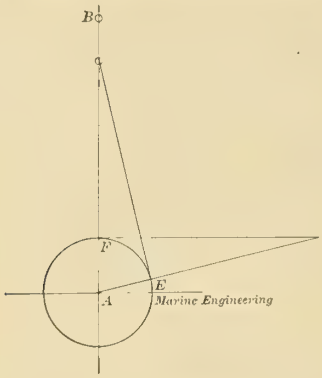


FIG. 11.

crank pin circle, $A\ B$ is the total distance from center of shaft to center of crosshead (equal to length of crank $A\ F$ + length of connecting rod $F\ B$). Then the angle $A\ E\ C$ being a right angle,

$A\ C^2 = E\ C^2 + A\ E^2 \therefore A\ C = \sqrt{E\ C^2 + A\ E^2}$, in the present case—

$$A\ C = \sqrt{4^2 + 1^2}\ \sqrt{17} = 4.123.$$

The distance $C\ B$ is therefore equal to $(A\ F + F\ B) - A\ C = (1 + 4) - 4.123 = .877$ ft. or 10.524 in., i. e., the piston is (12 — 10.524) 1.476 in. from the center of its stroke, and this becomes another point on the inertia curve of the diagram.

The Oceanic Steamship Co. is reported to be negotiating with the Cramps for the construction of two 6,000-ton 17-knot steamships to be added to their transpacific fleet.

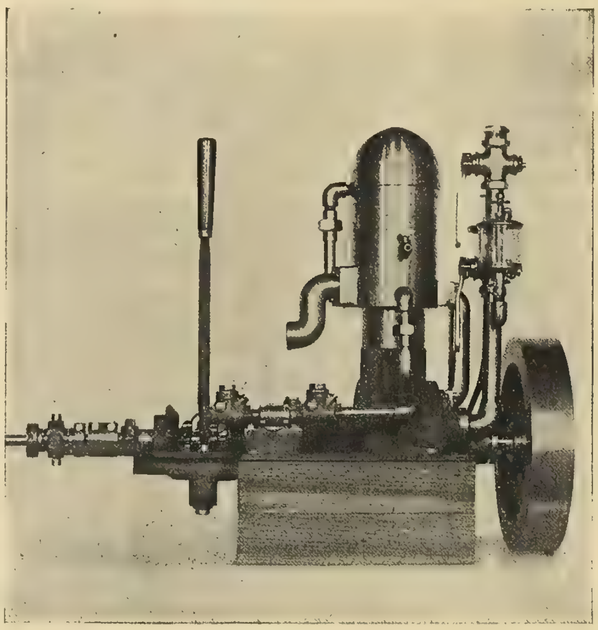
As showing the severity of weather on the Atlantic this year, a recent trip of the Cunarder *Lucania* may be cited. She ran just 121 knots in twenty-four hours on a westward trip in February, which lasted altogether eight days.

The auxiliary gunboat Gloucester, formerly the S. Y. *Corsair*, which was chiefly responsible for the destruction of the Spanish destroyers *Furor* and *Terror* at Santiago, is now in service at the Naval Academy for target practice drills.

IMPROVED APPARATUS.

Yale Marine Gas Engine.

Our illustration shows a Yale improved two-cycle marine gas engine which, the makers assert, contains many points of superiority over engines previously built on this system. The design is neat and simple and complete: the bed-plate is light, though very strong, and it carries the reversing gear, universal joint and ball-bearing thrust collars. The latter are arranged to bear on gimbal rings, so that any slight change in the alignment of the engine or stern bearing is compensated for without cramping the shaft, a point of real importance. The circulating water overflows into the exhaust, and, in connection with an improved muffler, eliminates the objectionable features of noise and smell. The fuel tank, in all cases, is put low down in the boat, and a circulating pump is arranged to keep a constant supply in a receptacle located between the two controlling valves shown on the stand-pipe. The air is drawn into the base through a patent rotary valve which opens and closes the suction and transfer ports with absolute certainty and no back pressure. The fuel is forced up from this receptacle by atmospheric pressure and instantly flashed into gas at each stroke of the piston. Under this system it is impossible to flood the engine. When kerosene oil is used (which can be readily done), substantially the same system is adopted, except that the fuel is drawn through a special vaporizer. By feeding a proper amount of lubricating oil in with the air supply, all difficulties of lubrication of the crank and bearings are overcome. In the two-cycle engine a power

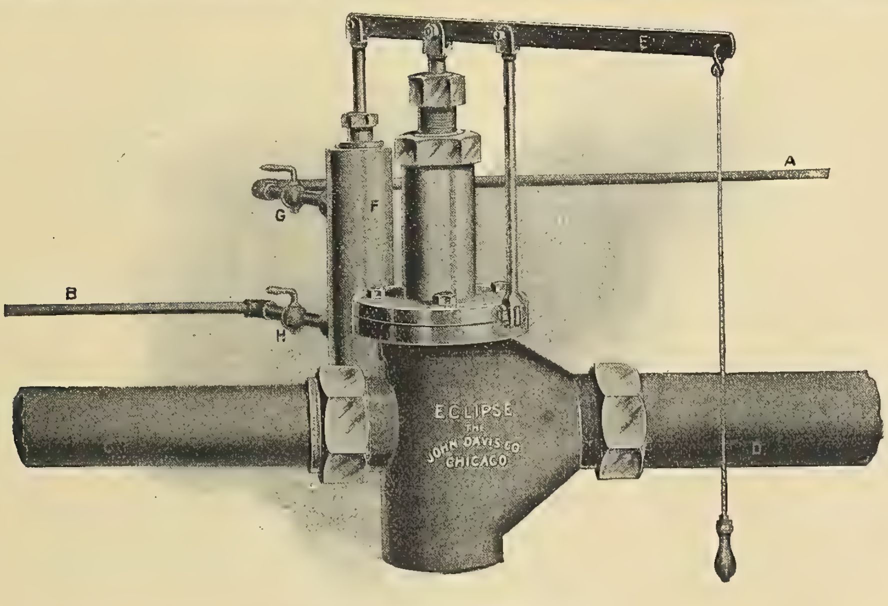


YALE MARINE GAS ENGINE.

impulse is secured at every complete revolution of the engine. The charge is first drawn into the base and there slightly compressed, then it is transferred to the top of the cylinder, where it is further compressed on the following up-stroke, a new charge being drawn into the base of the engine at the same time. At the height of the compression, as the piston goes over the top center, a spark is produced by suitable batteries and coils igniting the charge and causing the resultant expansion from which the power is derived. This system presents advantages for marine work; the explosions are somewhat lighter than in the four-cycle engine, and there being double as many for a single cylinder less vibration is occasioned, thus permitting a lighter fly wheel and the running of a single-cylinder engine at low speeds. As the throws of the crank in this engine are balanced, the makers claim that it is the smoothest-running marine engine of this type on the market. The engines are manufactured by The Denison Electric Engineering Co., New Haven, Conn., in sizes from 1 H. P. to 45 H. P. The company also makes a specialty of direct-coupled outfits for yacht and ship lighting, to use kerosene oil if required.

Eclipse Stop Safety Valve.

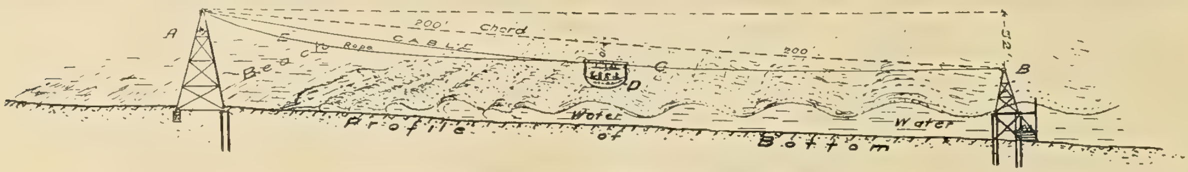
A broken steam main is a mishap which is, perhaps, more dreaded by the engineering staff of a vessel than any other mishap which might ordinarily occur. To prevent disastrous results from an accident of this sort the Eclipse Stop and Safety Valve has been designed. It is intended to automatically shut off the steam in case of any break in the main or branches. The valve is placed on the steam line as near the boiler as practicable—the main is indicated by *D* and *C* in the engraving. Connection is made by the small pipe *A* with the steam drum, or dome, or top of the boiler, and the pipe *B* taps the steam main beyond the valve in the direction of the engine. To put the valve into operation it is necessary to open the cocks *C* and *H* and pull down the lever *E*, until the main valve is wide open. Should a break occur in the main at any point between this valve and the engine the steam pressure under the piston in the cylinder *F* would drop, and the excess of pressure coming from the boiler through pipe *A* over the piston would cause it to descend sharply and so close the valve. When equilibrium was restored in the cylinder *F* the main valve could be opened again by pulling down on lever *E*. This valve is manufactured and kept in stock in sizes ranging from 1 in. to 12 in. by The John Davis Co., 79 Michigan Ave., Chicago, Ill.



ECLIPSE STOP SAFETY VALVE.

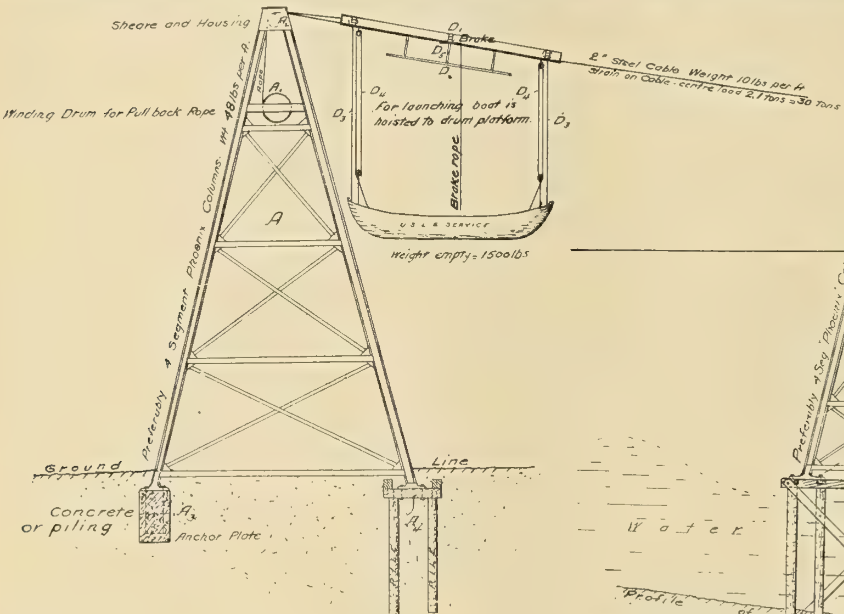
Chance Launching Cableway.

The want of some better means of launching surf boats than directly from the sand has been felt for many years, and various apparatus for launching has been brought out, but generally with very poor success in service. The devices are usually too clumsy to be easily moved from place to place, yet not sufficiently stable for location permanently in a good situation, and are frequently as dangerous to handle as the boat itself. The aparatus here shown consists of two towers *A* and *B*, a steel cable *C*, and boat-launching device *D*. The launching cableway consists of two towers, a shore tower, placed at about high-water mark, and a sea tower placed at a distance of about 400 ft. off. This distance, of course, may be varied to suit the depth of water and topography of the shore line. Other towers may also extend farther out. There is a steel cable between the towers, passing over sheaves at each end, and at the shore end there is an arrangement consisting of springs and pulleys to take up the jar and stretch of cable. The launching device or the surf-boat carrier is hung on trolley wheels, shown in the drawing, the wheels revolving on axles bearing in suitable boxes. The boat is hoisted to place by pulley blocks, and after having been so hoisted, the ropes of the hoising blocks are made fast and drop ropes D_3 D_3 attached. These ropes have releasing arrangements so that the boat can be dropped slowly or instantaneously by one man. The hoisting ropes are put away after hoisting on the platform D_2. Pullback rope *E* is for the purpose of pulling back the carriage after launching. The towers would be made of Bessemer steel throughout, and the cable of the "patent locked wire" pattern, with an ultimate tensile strength of 157 tons. The main tower is planned to



CHANCE LAUNCHING CABLEWAY IN OPERATION.

be 50 ft. high, the sea tower 24 ft. high, the span of cable 400 ft., the drop of rope from one tower to the other 32 ft., the cable 2 in. in diameter. The piling and timbers are 12 in. square. The concrete and rock

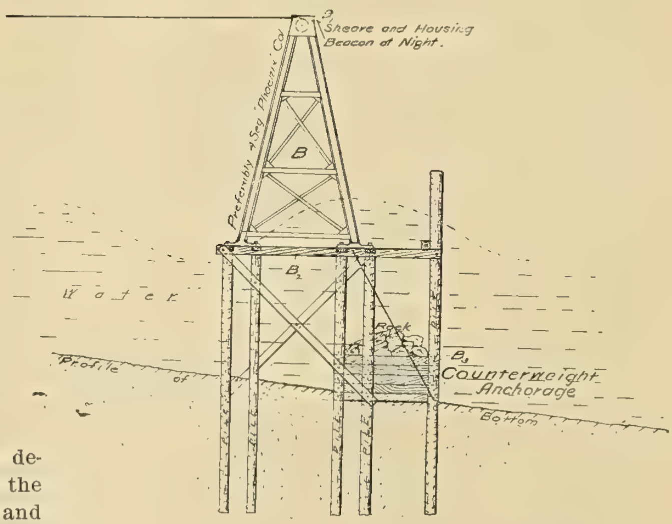


CHANCE CABLEWAY—SHORE END.

shown act as counterbalances. In operating the device the boat is hauled beneath the shore end of the cable, and hoisted to place by the sheave blocks and falls as shown in the drawing, marked D_4 D_4. After hoisting to the level of the drum the fall ropes are made fast to clevis on blocks by two men, and the ends of ropes put on the platform D_2. The release ropes D_3 D_3 are then attached, the brake D_5, shown, being set. The remainder of the crew enters the boat after it has been hoisted to place and ready for release. The last man to enter the boat releases the pullback rope; the brake is then released and the boat runs by gravity to within about 50 ft. of the sea tower. The release ropes are then let go, releasing gradually or rapidly, and the boat drops to the water. The carriage D is pulled back to shore tower by the pullback rope. This device is the invention of G. W. Chance, C. E., Drexel Building, Philadelphia, Pa.

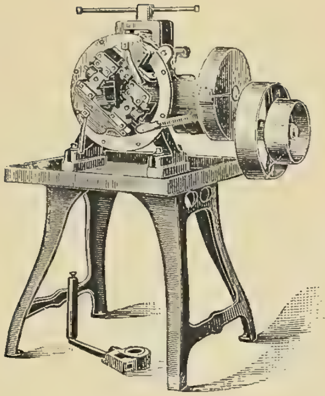
Armstrong Pipe Threading Machine.

A new machine, which has just been placed on the market by the Armstrong Mfg. Co., of Bridgeport, Conn., is shown in the accompanying illustration. It is built on the same general plan as smaller machines manufactured by the company, but has important modifications. The new machine will thread pipe from 1 in. to 4 in. dia. It uses the regular Armstrong stock dies, which are put into the machine and adjusted in the same manner as the hand stock. The dies can be opened after cutting the thread, and when the pipe is removed can be locked back to the stand-



CHANCE CABLEWAY—OFF-SHORE END.

ard size without resetting. This is accomplished by an automatic locking device, which is operated by pulling a lever. This lever is shown at the left of the illustration. The dies, however, can be adjusted to variations of fittings the same as in the stock. All gears and moving parts of the machine run in oil, being enclosed in a chamber which covers them from chips and dust. The die head has no teeth on the part where it fits into the shell and forms a bearing, in this way preserving its bearing surfaces and making it imposible to get loose. In addition to this bearing being preserved by not revolving on top of the gear teeth, there is an inner journal of large diameter, thereby still increasing the wearing surface and preventing the die head from becoming loose. A powerful self-centering disk is used with this machine, and will hold the pipe, being threaded, with a light pressure of the lever. The construction of the machine ad-

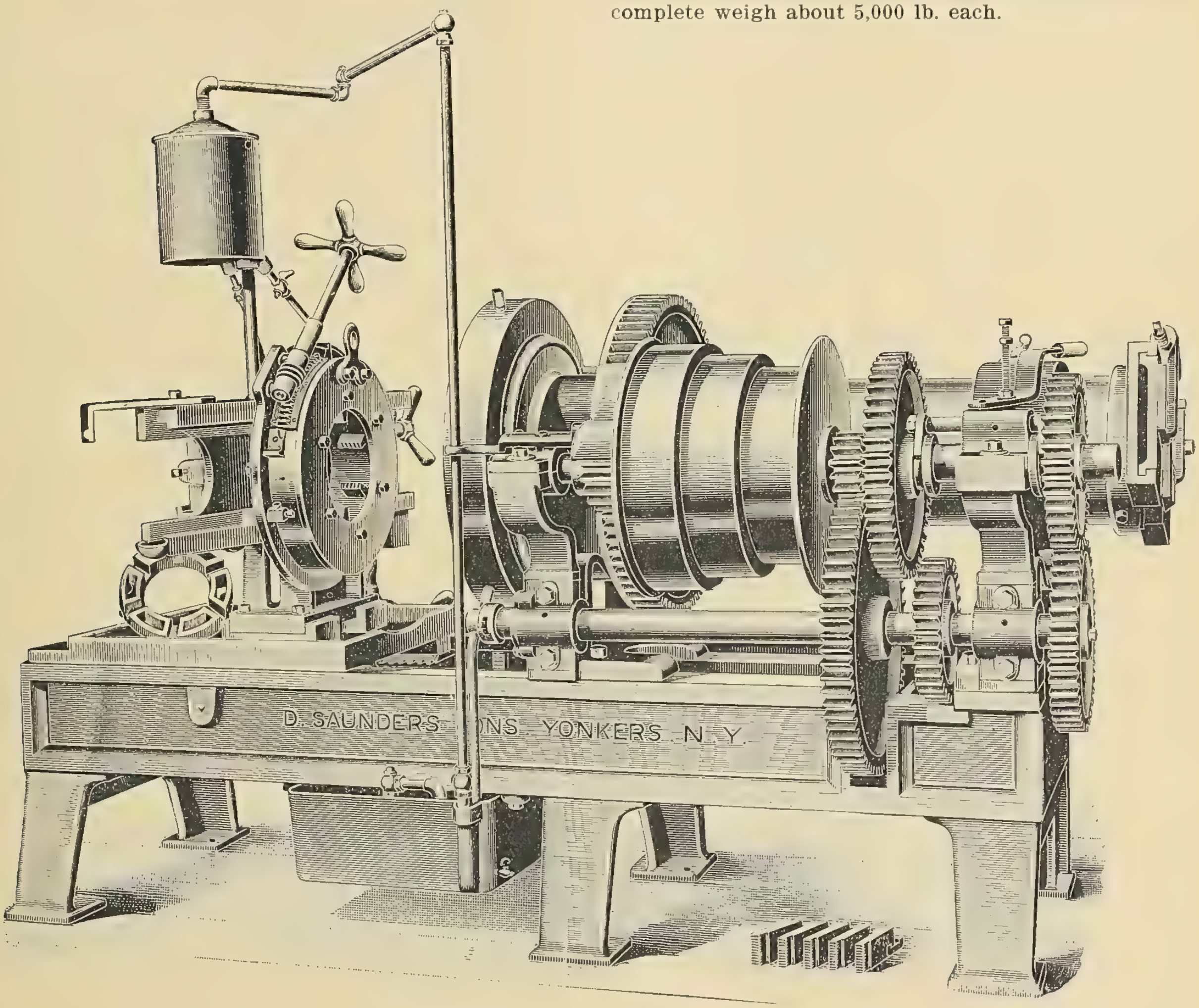


ARMSTRONG THREADING MACHINE.

mits of its being fastened to a bench or placed in an iron stand, which is furnished when desired. The machine here shown is designated as No. 00, and has a cutting off attachment for cutting pipes the same as the Armstrong Co.'s larger machines. The total weight of the new machine, without the stand, is 370 lb.

Pipe Threading and Cutting Machine.

The accompanying illustration shows the back view of a pipe threading and cutting machine especially adapted for use in marine and ship building plants, manufactured by D. Saunders' Sons, of Yonkers, New York. The machine is designed to thread and cut off pipe from one and a quarter to eight inches in diameter. The belting and gearing are arranged so as to obtain suitable power and speed for these various sizes of pipe, and so proportioned as to give a nearly uniform surface speed for each size. The use of large pulleys and tight belting is avoided. Variations of speed are obtained by cone pulleys as well as by gearing which is changed by the movement of a lever. No loose gears are used. Short pieces of pipe can be threaded without the use of a nipple chuck. After the pipe has been threaded the die head may be pushed to one side, allowing ample room for the pipe to pass through the cutting head without passing through the die head. By this arrangement pipe is alternately threaded and cut off without removing the die head from the machine. The steel jaws of the machine are adjustable to compensate for wear. An automatic oil pump, shown in the illustration, is attached to each machine. These machines complete weigh about 5,000 lb. each.



SAUNDERS' PIPE THREADING MACHINE.

Marine Engineering

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IN a spirit of compromise Congress passed the Naval Appropriation Bill before adjournment last month, and for this reason the expected naval shipbuilding programme will not be immediately carried out. The bill as passed provides for the construction of three first-class battleships, three first-class armored cruisers, and three protected cruisers, and fixed the maximum price of armor at three hundred dollars a ton, with the further clause that none of the armored vessels shall be built until the armor is provided for. The number of ships is three less than the number recommended by the Navy Department, the difference being in the cruiser class. By fixing the price of armor at such a low figure, and adding the restriction of letting contracts only after the armor has been provided for, Congress has practically prevented the immediate construction of the new armored vessels. The armor dispute is one which has raged now for a long period without any satisfactory solution. It ought to be within the power of Congress to find out what is a fair price to pay for armor plate, and then, knowing this, to act intelligently. Setting an arbitrary price for material and holding the club of a Government plant over the head of the steel makers is not a very dignified position for the Government to occupy—in fact it might be mildly called intimidation. But even supposing the steel makers to be at fault, that they charge exorbitant prices and take advantage of the country's necessity, is that a good reason why the building of naval vessels for the defence of the honor and interests of the country should be stopped? It is hard to see how the opponents of the armor plate purchases can occupy any reasonable ground for their opposition—possibly the explanation is in some petty local or party advantage. Armor is a very expensive material, costly to produce, so much so, indeed, that the actual material bears little relation to the price. This has a parallel in many branches of manufacture. The loaf of bread is dear or cheap according to the rise or fall of the price of flour, but the price of the finer grades of lace is not based on the cost of linen thread. The production of armor plate necessitates the use of very costly apparatus, not only in forging the plates, but in machining them according to design. Then the orders for such material are neither sure nor continuous, and the makers run the risk of having an enormous amount of capital locked up in idle machinery. The price paid for armor by other nations could be readily ascertained, and if a comparison of such prices with those made by our steel makers showed that the latter were unreasonable or exorbitant an opportunity to bid could be given to all comers, home and foreign. This would settle the matter effectually, and there would be little chance of the orders going outside of this country. There seem to be some influences at work in Congress in cutting down the amount of appropriations where the Navy is concerned, which are not helpful to the best interests of the country in any sense. This was especially noticeable in the appropriations for the last lot of torpedo boats and destroyers, and cropped out in the case of the new monitors, and now appears in connection with armor plate. Some of the rural members of Congress seem to believe that war ships and their components are bought and sold like horses at a country show—for what they will bring. A horse buyer gets the horse at the lowest price he can, knowing the qualities of the beast will not be changed thereby; a ship is an entirely different proposition, for there the quality has a close relationship to the price. However patriotic a manufacturer may be, he can only afford to give the Government what it pays for—nothing more. It ought to be the aim of the Government to encourage manufacturers and help to develop the manufacturing resources of the country which could be drawn on in time of need. The proposition to build a Government armor plate plant touches upon the ridiculous. To begin with, it would entail such a delay in the completion of the ships provided for in the bill that they would be almost out of date when completed. To operate such a plant with any degree of economy necessitates a certain and constant output. Do the advocates of the Government plant propose to build an indefinite number of armored vessels to keep the armor plant busy? Why, even the British Government, with its enormous Navy, does not manufacture a ton of armor plate. It has always been the policy of governments to so distribute the manufacture of war matériel that any local mishap, such as breakdown, fire, etc., will not paralyze the fighting resources of the nation. The recent action of Congress in this matter is childish and unworthy of the national legislature.

GREAT as was the achievement of the officers and men in bringing the U. S. S. *Oregon* safely around Cape Horn from the Pacific to the Atlantic, a run of 14,000 miles, it is now overshadowed by the voyage of the same ship from New York to Manila, a distance of 20,000 miles; and arriving out, in the words of Admiral Dewey, "in fit condition for any duty." This later run has not attracted nearly as much public attention as the run during the Spanish war, for the very natural reason that the country was then at war on the sea with a civilized power, while now the operations in the East are practically confined to the land, and are with a semi-civilized or barbarous foe. But the trip to Manila is really the more remarkable performance, from an engineering point of view. There was less incentive for those on board to put forth extraordinary efforts: on the previous run officers and men knew that they were on their way to fight for their country in the cause of liberty. On the other hand, however, the voyage just completed was made with the aid and benefit of the information and experience of the vessel's capabilities gained on the voyage around the Horn. That memorable voyage was in the nature of an experiment, and this calls attention to the apparent lack of confidence in the sailing qualities of the modern battleship. No other first-class ship of this type has made such records as the *Oregon* holds; though some long voyages have been accomplished by ships of other nations, notably the British. It is curious to compare the attitude of naval authorities with the practice which obtains in the mercantile marine. It is nothing remarkable for an ordinary cargo vessel to make a seventy-day voyage under steam, and even in winter the ordinary tramp crosses the ocean without any one interested taking any special credit. The design and uses of such vessels are altogether dissimilar, and yet both are sea-going ships and as such should be able to meet any conditions. It may be that Navies have exercised an undue amount of caution in this respect and that the example set by the *Oregon* will be extensively followed.

RUMORS of the formation of a shipbuilders' trust on the Great Lakes are in the air, though at this time of writing nothing definite has transpired. This trust would embrace most of the large establishments, though several works would be on the outside. The modern tendency in manufacturing and commerce is toward concentration of effort. In these respects the ordinary stock company may be regarded as a trust, for it is organized, usually, to carry on a more extensive business under one management than could be undertaken independently by any of the stockholders. The result is, also usually, a benefit to the community at large, as in the case of the railroad and steamship corporations—the stockholders stand any losses. When, however, a trust or combination of separate interests is formed for the purpose of controlling the exclusive right, under patents, to manufacture certain articles or to control the natural resources of a country, the existence of such a trust is generally a luxury that the consumer pays for. In the case of most manufactured articles the carrying out of processes on a large scale gives the most economical results, and the expenses of marketing are largely reduced. In this, however, as in everything else in commercial life, there is a conflict of interests, for centralization of power dispenses with many capable and high-salaried men who managed the scattered units. Herein, we understand, lies the difficulty of forming a lake shipbuilders' trust. It is one thing to be the head of a large works, responsible to no official head, and quite another to be an employee accountable for every act. As a shipbuilders' trust would control no fundamental patents nor natural resources it is not likely that it would work to the disadvantage of the shipowner. A combination of several of the largest pump manufacturers of the country is also announced under the title of The International Steam Pump Company. This combination includes several of the well-known makers of marine pumps. The capital stock of the new organization is fixed at $27,000,000.

MARINE BREAKDOWNS AND LOSSES.

NARRATIVE OF THE MISHAPS WHICH BEFELL SOME WELL-KNOWN LINERS.

In marine circles the early months of the present year will long be remembered for the numbers of disasters and mishaps of every variety occasioned by the unusually severe weather. Leaving out of reckoning the wrecks of scores of small vessels, the losses of many large well-equipped steamships brought sadness to many homes and substantially decreased profits in shipping and insurance circles. It is rather remarkable, however, that in many instances the loss of a vessel or her total disablement was not attended by any loss of life. Some of the most notable mishaps are recounted here, with views of the steamships, *Bulgaria* of the Hamburg-American line, *Pavonia* of the Cunard line, and *Castilian* of the Allan line.

The Hamburg-American line freight and passenger steamship *Bulgaria* had an eventful voyage, which commenced January 28 at New York and ended February 24 at Ponta Delgada, Azores. The vessel left her pier at Hoboken on the Hudson river on her regular eastward trip to Hamburg, carrying a large cargo, many head of horses, and forty-one passengers in the steerage. Nothing unusual occurred until the night of February 1, when a terrific hurricane was encountered. The vessel was unable to make any headway and next afternoon Captain Schmidt decided to heave to. While being pounded by the waves the entire steering gear was carried away, according to the report of the ship's officers, and then the *Bulgaria* was helpless. Immense seas swept over the vessel, carrying away all sorts of gear and smashing windows and doors in the deck houses, and finally carrying overboard some of the hatch covers. Then the vessel commenced to fill, and she is said also to have sprung a leak. The horses carried stampeded and trampled each other or were dashed against the sides and killed, and those maimed were slaughtered. Later the vessel took a heavy list to port, and this increased the terror of the passengers, who were already demoralized. For seventy-two hours the crew labored to jettison the cargo and lighten the vessel, but the water kept rising in the holds and soon was nearly up to the grates in the fireroom, though the trimmers and firemen kept at work. On February 5 three steamships were sighted, and one of these, the tank steamer *Weehawken*, from Philadelphia for Hull, stood by and took off twenty-five passengers. She was unable to render further assistance, as her holds were full of water, and she lost all her small boats. This occurred in latitude 40 north, longitude 43 west. The *Weehawken* then proceeded to the Azores, where she landed the *Bulgaria's* passengers at Ponta Delgada. Her report of the condition of the *Bulgaria* at the time they parted caused intense anxiety for the safety of those on board the liner, and by many the *Bulgaria* was given up for lost. While the *Weehawken* was taking off the passengers four of the crew of the *Bulgaria* put off in an open boat, and after being blown about for several hours they were picked up by another of the steamers, the *Vittoria*. An officer and several of the crew of the *Vittoria* then got into the boat with the intention of going aboard the *Bulgaria*, but they could not reach her owing to the weather, which had become more severe, and they had great difficulty in getting back to their own ship. The Captain of the *Vittoria* determined to keep the *Bulgaria* company, so that he could give assistance when the storm abated, but in the night he lost sight of the distressed vessel, and he continued westward and put into Baltimore, where he landed the four mariners of the *Bulgaria* on February 22. Meanwhile on the *Bulgaria* matters improved somewhat after the *Weehawken* left, for the weather became calmer, and repairs were attempted. On February 11, however, stormy weather returned, and after about three more days of drifting the British steamer *Antillian*, bound west from Liverpool for New Orleans, came up. She was asked to tow and passed a hawser to the *Bulgaria*. After several hours the tow line parted and another was secured, with a like result, so that finally the *Antillian* steamed away, as Captain Schmidt would not abandon his ship. February 17 the Norwegian bark *Helga* was signaled to report the *Bulgaria* "all well." Three days afterward, when the wind and sea had gone down considerably, repairs to the steering apparatus of the *Bulgaria* were completed and she proceeded under her own steam, shaping her course for Ponta Delgada. She averaged about ten knots speed and arrived in harbor February 24. Many of her passengers and crew had sustained severe injuries owing to their being thrown about violently during the storms. The seamanship displayed by the Captain and officers and the faithfulness and skill of the engineering staff called out widespread expressions of praise among marine folk, and the owners received a special message of congratulation from Emperor William. The *Bulgaria* is a new steamer of German build, having been launched from the yard of Blohm & Voss at Hamburg early last year. She is a large cargo-carrying boat of the intermediate type, measuring: Length, 500 ft.; beam, 62 ft.; depth, 38 ft. She is built of steel and is fitted with twin-screws, with quadruple-expansion balanced engines, with cylinders 21 1-3 in., 31 2-5 in., 46 in., and 66 1-2 in. by 48 in. stroke. She has Scotch boilers. Her gross tonnage is 10,961 tons.

The magnificent new Allan line steamship *Castilian*, Captain Richard Barrett, was lost on the morning of March 13, when in a thick fog she went on the Gannett Rock Ledges, about 11 miles southwest of Yarmouth Light, Nova Scotia. This was her maiden voyage and she had touched at Portland, Me., on her way out. When the mishap occurred the weather was moderate and the sea comparatively calm. Considerable water was reported after she struck as coming into the forward compartments. The chief officer and a boat's crew were sent for assistance and made a landing at Little River, and from there information of the mishap was conveyed to Yarmouth, from whence three steam tugs immediately came out. There were about fifty passengers on the *Castilian*. These were all taken off, together with a number of the crew, although the officers and some of the crew stood by the ship. The course which the vessel was steering at the time is hedged about with many dangers in the shape of ledges and reefs, and there are strong currents and tides. It was reported at the time that the compasses were deranged and that this accounted for the vessel being about twenty miles off her course. Subsequently the vessel broke in two and was a total loss. She carried a general cargo valued at about $500,000 and many head of cattle. The *Castilian* was probably the largest vessel in the Canadian Atlantic trade. She was launched October 19, 1898, from the yard of Workman, Clark & Co., of Belfast, Ireland. Her design provided for a first-class passenger, cattle and cargo vessel of about 8,500 tons cargo capacity. Her dimensions were: Length, 470 ft.; beam, 53 ft. 9 in.; depth, 36 ft. She was built in excess of registry requirements, had a cellular bottom, nine water-tight compartments and three steel decks running the entire length fore and aft. There was a permanent shelter deck with bridge deck above. The cabin passengers were accommodated in the bridge enclosure amidships, where the furnishings and fittings were unusually artistic. The main saloon had accommodation for 100 passengers at table at one sitting. The roof of the deck house was used as a promenade, giving an unbroken stretch of 150 ft. in length at a height of about 25 ft. above the water. Very pleasant quarters for the second-class passengers were fitted aft, including a dining room with seating capacity for 150 persons. There was accommodation for a large number of steerage passengers on the main deck, and extensive accommodation for the large crew carried. Ex-

Allan Line S.S. Castilian. *Hamburg-American Line S.S. Bulgaria.* *Cunard Line S.S. Pavonia.*

MISHAPS TO THESE TRANSATLANTIC LINERS CAUSED MUCH ANXIETY LATELY.—FOR PARTICULARS SEE OPPOSITE PAGE.

tensive refrigerating and electric light plants were fitted, and all the navigating and deck appliances were of the most improved types. She was fitted with comparatively powerful engines, and on her voyage out averaged about 300 miles a day.

The Cunard liner *Pavonia*, on the Boston-Liverpool route, set sail from Queenstown westbound late in January, and was towed into St. Michaels, Azores, February 18, by the British steamship Wolviston. Then was related an extraordinary story of misadventure. Shortly after the vessel left Queenstown she encountered a succession of hurricanes, and had to lay to at intervals for hours at a stretch. Finally in some unexplained manner the boilers got adrift and added to the terrors of the passengers by pounding about as the vessel rolled. The steamship *Colorado* was afterward sighted and passed a line to the *Pavonia*, but the towing bitts pulled out, and the Captain of the Colorado had to content himself with standing by for about twenty-four hours, when he lost sight of the *Pavonia*. Meanwhile the Cunarder was in a deplorable condition. The engineers, aided by their staff and deck officers and crew, made repeated efforts to secure the boilers, working in the semi-blackness of the stokehold unremittingly, while the ship was rolling and pitching terrifically and the water was waist high. The British steamship *Horatio* was sighted later, and in response to rocket signals approached and was notified of the *Pavonia's* condition. According to report the *Horatio* refused aid and went on her course. For another week the Cunarder drifted helplessly about, blown hither and thither by storms, until finally the steamship *Wolviston* was sighted. After about two days of effort in securing and losing tow lines the *Wolviston* made headway with the *Pavonia* in tow and the Azores were reached without further mishaps. The troubles of those on board the *Pavonia* were not over, however, as they had to land in life boats in a heavy gale. The conduct of most of the officers during those trying days was most warmly commended by the passengers, though there were many criticisms regarding the attitude of the Captain. The passengers were finally brought on here in the Portuguese steamship *Vega*, arriving at New York March 7. The *Pavonia*, like the other vessels of the Boston branch of the Cunard line, was not a flyer. She was a comparatively old ship, having been built at Clydebank in 1882. She is an iron barkentine-rigged single-screw ship of 5,500 gross tons, measuring: Length, 430 ft.; beam, 46 ft.; depth, 35 ft. She is fitted with two-cylinder compound engines and Scotch boilers.

The Dominion liner *Labrador*, bound east from St. Johns, N. B., and Halifax, N. S., for Liverpool, went ashore on McKenzie Rock, near Skerryvore Light on the Hebrides, on the morning of March 1. The ship was caught amidships and the seas broke over her so that the holds were soon full of water. The ship had good weather for several days out, but entered a fog bank some time before she was lost, and was away off her course at the time. The boats were got out and took off the passengers and crew, all of them being picked up by the steamship *Viking*, which happened to come up, except one boat load which made a landing at Skerryvore Light. This boat contained one Agoncillo, the blatant agent of Aguinaldo, leader of the Filipino rebels. His behavior was reported as being very cowardly when the vessel struck. The ship struck bottom very unexpectedly, and there was very little time to get away, but owing to the good discipline which prevailed no one was injured. The vessel had a valuable cargo and mails on board. The *Labrador* was a steel schooner-rigged screw steamer of about 4,700 gross tons and was built in 1891 by Harland & Wolff, Belfast, Ireland. Her dimensions were: Length, 400 ft.; beam, 47 ft.; depth, 28 ft. She was fitted with triple-expansion engines. This vessel held the record of the western passage from Liverpool to Halifax—about 7 1-2 days.

The Sloman line steamer *Moravia*, which was wrecked on the northeast bar of Sable Island about February 12, is reported a total loss. She was bound from Hamburg for Boston and was overdue. She carried no passengers and had a crew of thirty, who got away safely in the boats, but before they reached land one of the officers died from exposure. The *Moravia* was an iron ship of about 2,400 tons, built about fifteen years ago at Glasgow.

Interesting Salvage Cases.

The extraordinary photograph here reproduced, together with the following particulars, are copied from the *Engineer*, London. (Engraving on opposite page.)

The Milwaukee was a fine cattle carrier of large dimensions, owned by Messrs. Elder, Demster & Co., Liverpool, and left the Tyne in ballast early in September. When off the Aberdeenshire coast during a dense fog she stranded on an outlying rock, and all attempts to get her off proved fruitless. Without unnecessary delay salvage operations were commenced by the Liverpool Salvage Company, but, as the forepart was held fast by the rocks and immovable, it was deemed advisable to cut her in two, ahead of the boiler-room bulkhead, the after part being uninjured, and thus save the most valuable part. Being favored with fine weather, this was accomplished, with the aid of dynamite, thus saving nearly two-thirds of the ship, containing the engines, boilers, etc. This portion was taken in tow for the Tyne, where she recently arrived safely. It is intended to build a new bow and float it into dock to join the old portion.

The employment of what might be termed the hydraulic method of freeing vessels which had gone aground on a soft bottom was used successfully in the case of the of the British battleship *Victorious*, which recently stranded at Port Said. Her grounding was caused by the failure of her anchors to hold, and the combined influences of a strong wind and heavy sea. She touched bottom in about 25 ft. of water and later resisted all efforts to float her by the aid of tugs. A considerable quantity of coal, ammunition and other stores was removed to lighten the vessel. Then two boats with powerful pumps were put at work discharging water under pressure on the starboard side of the battleship, the nozzles of the discharge pipes being worked about below water where the bottom of the vessel rested on the sand. On the port side a suction dredge was put at work which removed the sand that was stirred up by the action of the jets. After about two days' work a sufficient excavation was made in the bottom to give a draught of water in which the vessel could float, and with the aid of tugs she was dragged out to deep water. The *Victorious* is one of the new British battleships, having been built at Chatham Dockyard in 1895. Her dimensions are: Length, 390 ft.; beam, 75 ft.; mean draught, 27 ft. 6 in.; displacement, 14,900 tons. A somewhat similar method was employed in freeing the Russian armored cruiser *Rossia*, which went aground in the river Neva. She settled nearly three feet in the bottom, which was composed of muddy sand mixed with a considerable percentage of pebbles. As the accident occurred in mid-winter, the vessel was soon frozen in, and all efforts to pull her off with tugs were useless. The hydraulic method was then employed, the nozzle from the discharge pumps being worked on the bottom where the vessel touched, and in this way she was floated after about three weeks' work, the conditions below water being explored from time to time by divers. The *Rossia* is an armored cruiser of the following dimensions: Length, 480 ft.; beam, 68 ft.; draught, 26 ft. Her displacement is 12,200 tons, and she is fitted with engines of 18,000 horse power, under forced draft, which give a maximum speed of 20 knots. She is fitted with triple screws driven by three sets of triple-expansion engines, and Belleville water-tube boilers. This fine vessel attended the British naval review at Spithead in 1897, and together with our *Brooklyn* attracted a great deal of attention. The *Rossia* was built at St. Petersburg.

EDUCATIONAL DEPARTMENT.

HELPS FOR CANDIDATES FOR MARINE ENGINEERS' LICENSES—MATERIALS OF ENGINEERING CONSTRUCTION—II.

BY DR. WILLIAM FREDERICK DURAND.

[2] Malleable Iron.

(1) *Composition and Manufacture.* If a casting of hard, white iron, or one with a large proportion of combined carbon, be packed in some material which will not fuse at a red heat, which will exclude the air, support the piece and prevent deformation when hot, and if it be then subjected to continuous red heat for some days, the combined carbon will be separated from the iron, but will not be able to collect together in flakes or scales or to form the same structure as in soft, gray cast iron. In consequence the iron crystals remain in more intimate contact, much as in steel, and the tensile strength and toughness are greatly increased.

It has long been supposed that this operation involved an actual withdrawal of the carbon from the iron, and to this end the substances usually employed are either the common red oxide of iron in the form of hematite iron ore, or the black oxide in the form of mill scale, or the corresponding oxide of manganese. These have a decarbonizing effect; that is, under the conditions existing they will to some extent withdraw the carbon from the surface layer of iron. Analyses of malleable iron show, however, that only to a slight extent is the carbon actually withdrawn as a whole, and that the principal change is in the condition of the carbon, as above explained. The surface effect, however, extending in, as it does, for perhaps 1-16 in., is undoubtedly a valuable feature, and while a good quality of malleable iron has been made by the use of river sand as a packing medium, the use of the substances mentioned above is rather to be preferred.

In order that the process may be successful, the iron must have nearly all the carbon in the combined state, and must be low in sulphur, as the latter substance is found to greatly increase the time necessary. It has been customary to use only good charcoal-melted iron in which the sulphur is very low, though a coke-melted iron is quite as suitable, provided the proportion of sulphur is correspondingly small. The process can rarely be applied to very large castings, because such, cooling slowly, usually show a considerable proportion of graphite carbon.

To carry out the process the castings are embedded in the material selected. The whole is then inclosed in a cast-iron box or pot and is subjected to a full red heat for from two or three days to as many weeks, depending on the size of the piece.

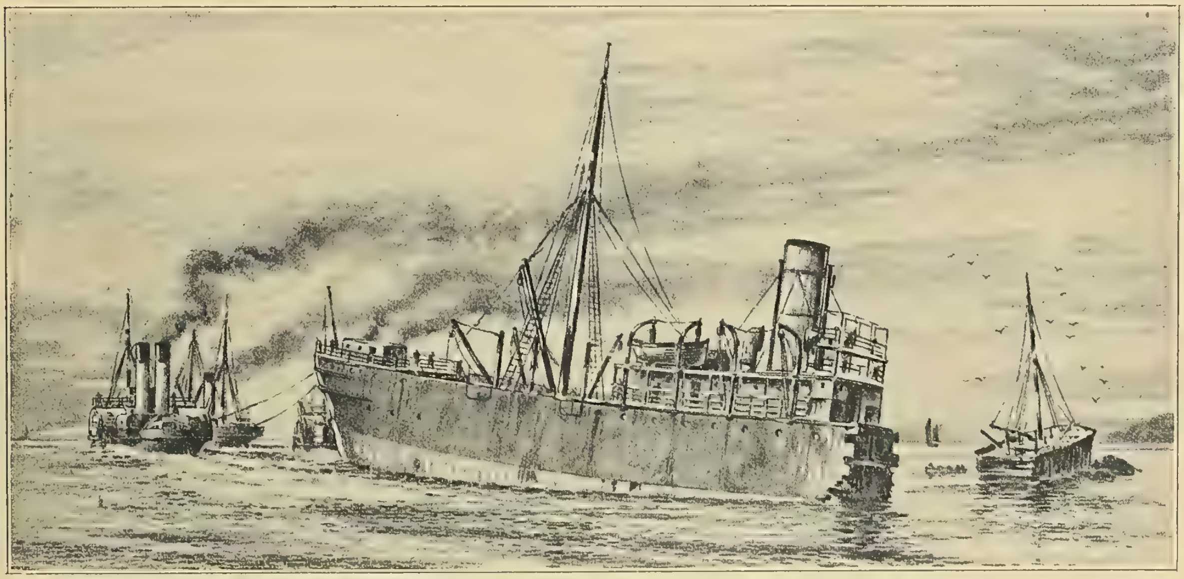
(2) *Physical and Mechanical Properties.* Outside of the numerical information, to be given later, attention may be called to the ductility of malleable iron, which is from four to six times that of cast iron, though only about one-tenth that of wrought iron. Nevertheless good malleable iron can be bent and twisted to a very considerable extent before breaking, and its ability to withstand blows or shocks is very much greater than cast iron. Malleable iron may with care be forged and welded, and it may be case hardened much as with wrought iron.

(3) *Uses in Marine Engineering.* Malleable iron is used for junction boxes and for pipe fittings in certain varieties of water-tube boilers, and to some extent for general pipe fittings on board ship. It would seem that the use of this material might with advantage be extended to many parts in which more strength and toughness are required than can be provided by cast iron.

[3] Wrought Iron.

(1) *Composition and Manufacture.* Wrought iron is nearly pure iron mixed with more or less slag. Nearly all the wrought iron used is modern times is made by the *puddling* process. For the details of this process reference may be had to text-books on metallurgy. We can only note here that in a furnace somewhat similar to the *open-hearth* referred to in [4] most of the carbon, silicon and other special ingredients of cast iron are removed by the combined action of the flame and of a molten bath of slag or fluxing material consisting chiefly of black oxide of iron. As this process approaches completion small bits of nearly pure iron begin to separate out from the bath of melted slag and unite together. This is helped along by the puddling bar, and after the iron has thus become separated from the liquid slag it is taken out, hammered or squeezed, and rolled down into bars or plates. Some of the slag is necessarily retained in the iron and by the process of manufacture is drawn out into fine threads, giving to the iron a stringy or fibrous appearance when nicked and bent over or when pulled apart.

The proportion of carbon in wrought iron is very



AFTER END OF THE S.S. MILWAUKEE IN TOW OFF THE COAST OF SCOTLAND.

small, ranging from .02 to .20 of one per cent. In addition, small amounts of sulphur, phosphorus, silicon and manganese are usually present.

The proportion of sulphur should not exceed .01 of one per cent. Excess of sulphur makes the iron *red-short*, that is, brittle, when red hot.

The proportion of phosphorus may vary from .05 to .25 of one per cent. Excess of phosphorus makes the metal *cold-short*, that is, brittle when cold.

The proportion of silicon may vary from .05 to .30 of one per cent.

The proportion of manganese may vary from .005 to .05 of one per cent. The influence of the silicon and manganese is usually slight and unimportant.

(2) *Special Properties.* Wrought iron is malleable and ductile, and may be rolled, forged, flanged and welded. It cannot be hardened as steel, though by the process of case-hardening a surface layer of steel is formed and may be hardened. Wrought iron may be welded, because for a considerable range of temperature below melting (which takes place only at a very high temperature indeed) the iron becomes soft and plastic, and two pieces pressed together in this condition unite and form on cooling a junction nearly as strong as the solid metal. In order to be thus successful, however, the iron must be heated sufficiently to bring it to the plastic condition, yet not overheated, and there must be employed a flux (usually borax) which will unite with the iron oxide and other impurities at the joint, and form a thin liquid slag which may be readily pressed out in the operation, thus allowing the clean metal faces of the iron to effect a union as desired.

(3) *Uses in Marine Engineering.* In modern practice the place of wrought iron in marine engineering has been almost entirely taken by steel. Its former office was for all moving parts requiring strength and toughness. It is still used to some extent for the stay bolts and braces of boilers, and for boiler tubes.

[5] STEEL.

(1) *General Composition.* The properties of steel depend partly on the proportions of carbon and other ingredients which it may contain, and partly on the process of manufacture. The proportion of carbon is intermediate between that for wrought iron and for cast iron. In the so-called mild or structural steel the carbon is usually from 1-10 to 1-4 or 1-3 of one per cent. In spring steel the carbon proportion is somewhat greater, and in high carbon grades such as are used for tool steel, etc., the carbon is from .6 to 1.2 per cent. In addition to the carbon there may be sulphur, phosphorus, silicon and manganese in varying but very small amounts.

From the proportion of carbon it follows that steel may be made either by increasing the proportion in wrought iron or decreasing the proportion in cast iron. The earlier processes followed the first method, and high-grade steels are still made in this way by the *crucible* process.

(2) *Crucible Steel.* In this process a pure grade of wrought iron is rolled out into flat bars. These are then cut and piled and packed with intermediate layers of charcoal and subjected to a high temperature for several days. This recarbonizes or adds carbon to the wrought iron, and thus makes what is then called *cement* or *blister* steel. These bars are then broken into pieces of convenient size, placed in small crucibles, melted, and cast into bars or into such forms as are desired.

Note.—Mild or structural steel is made wholly by the second general method—the reduction of the proportion of carbon in cast iron. There are two general processes, known as the *Bessemer* and the *Siemens Martin* or *Open-hearth.*

(3) *Bessemer Process.* In this process the carbon and silicon are burned almost entirely out of the cast iron by forcing an air blast through the molten iron in a vessel known as a converter. A small amount of *spiegel eisen* or iron rich in carbon and manganese is then added in such weight as to make the proportion of carbon and manganese suitable for the charge as a whole. The steel thus formed is then cast into ingots or into such forms as may be desired.

In this process no sulphur or phosphorus is removed, so that it is necessary to use a cast iron very nearly free from these ingredients in order that the steel may have the properties desired. A modification by means of which the phosphorus is removed, and known as the *basic* Bessemer process, is used to some extent. In this, calcined or burnt lime is added to the charge just before pouring. This unites with the phosphorus, removes it from the steel, and brings it into the slag. In the basic process the lining of the converter is made of gannister or a calcined magnesia limestone, in order that it may not also be attacked by the added limestone and the resulting slag.

In that form of Bessemer process first noted, and often known as the *acid* process in distinction from the latter or basic process, the lining of the converter is of ordinary fire clay or like material.

The removal of the phosphorus by the basic process makes possible the use of an inferior grade of cast iron. At the same time, engineers are not altogether agreed as to the relative values of the two products, and many prefer steel made by the acid process from an iron nearly free from phosphorus at the start.

(4) *The Open-hearth Process.* In this process a charge of material consisting of wrought iron, cast iron, steel scrap, and sometimes certain ores, is melted on the hearth of a reverberatory furnace heated by gas fuel on the Siemens Martin or regenerative system. The carbon is thus partially burned out in much the same manner as for wrought iron, and the proportion of carbon is brought down to the desired point or slightly below. A charge of spiegel-eisen or ferromanganese is then added in order that the manganese may act on any oxide of iron slag which remains in the bath, and which would make the steel red-short if allowed to form a part of the charge. The manganese separates the iron out from the oxide, returns it to the bath, while the carbon joins in with that already present, and thus produces the desired proportions.

Here as with the similar operation with the Bessemer converter there is no removal of either sulphur or phosphorus, and only materials nearly free from these ingredients can be used for steel of satisfactory quality. With very low carbon, however, a little phosphorus seems to be desirable to add strength to the metal. This limitation of the available materials has led, as with the Bessemer process, to the use of calcined limestone, which unites with most of the phosphorus and holds it in the slag. Here, as in the Bessemer process also, it is necessary to use a basic lining for the furnace, and it is known as the *basic* open-hearth process. By distinction the method without the use of the limestone has come to be known as the *acid* open-hearth process.

As between the products of these two kinds of open-hearth process, there is much difference of opinion among engineers. *Either* will produce good steel with proper care, and *neither* will without it. It is usually considered sufficient to specify the allowable limits for the proportions of phosphorus and sulphur and leave the choice of the acid or basic processes to the maker.

(5) *Open-hearth and Bessemer Steels Compared.* Open-hearth steel is usually preferred for structural material in marine engineering. This is because:

(a) It seems to be more reliable and less subject to unexpected or unexplainable failures than the Bessemer product.

(b) Analysis shows that it is much more homogeneous in composition than Bessemer steel, and experience shows that it is much more uniform in physical quality. This is due to the process of manufacture, which is much more favorable to a thorough mixing of the charge than in the Bessemer process.

(c) The open-hearth steel may be tested from time to time during the operation, so that its composition may be determined and adjusted to fulfil specified conditions. This is not possible with the Bessemer process, and the latter product is therefore not under so good control as is the open-hearth.

(6) *Influence of Sulphur on Steel.* Sulphur makes steel red-short or brittle when hot, and interferes with its forging and welding properties. Manganese tends to counteract the bad effects of sulphur. Good crucible steel has rarely more than .01 of one per cent. In structural steel the proportion may vary from .02 to .08 or .10 of one per cent. When possible it should be reduced to not more than .03 or .04 of one per cent.

(7) *Influence of Phosphorus on Steel.* Phosphorus increases the tensile strength and raises the elastic limit of low carbon or structural steel, but at the expense of its ductility and toughness or ability to withstand shocks and irregularly applied loads. It is thus considered as a dangerous ingredient, and the amount allowable should be carefully specified. This is usually placed from .02 to .10 of one per cent.

(8) *Influence of Silicon on Steel.* Silicon tends to increase the tensile strength and to reduce the ductility of steel. It also increases the soundness of ingots and castings, and by reducing the iron oxide tends to prevent red-shortness. The process of manufacture usually removes nearly all of the silicon, so that it is not an element likely to give trouble to the steel maker. The proportion allowed should not be more than from .10 to .20 of one per cent.

(9) *Influence of Manganese on Steel.* This element is believed to increase hardness and fluidity, and to raise the elastic limit and increase the tensile strength. It also removes iron oxide and sulphur, and tends to counteract the influence of such amounts of sulphur and phosphorus as may remain. It is thus an important factor in preventing red-shortness. The proportion needed to obtain these valuable effects is usually found between .20 and .50 of one per cent.

(10) *Semi-steel.* A metal bearing this trade name has in recent years attracted favorable attention among engineers, and has come into considerable use where somewhat greater strength and toughness are required than can be provided by cast iron.

Semi-steel is made by melting up mild steel scrap, such as punchings and clippings of boiler plate, with cast iron pig, in the proportion of about 25 or 30 per cent of the former to 75 or 70 per cent of the latter. The presence of manganese and other special fluxes in small proportions is also found to add essentially to the strength, toughness and good machining qualities of the product. In this way is obtained a material having a tensile strength of 35,000 lb. or over, and a toughness and ability to withstand shocks decidedly greater than for cast iron, and with fairly good machining qualities. Semi-steel casts as readily as most grades of cast iron, and its shrinkage and general manipulation are about the same. The chief drawback seems to lie in the danger of hardness under the lathe, planer or boring tool, but with the proper mixtures this is avoided, and a material very satisfactory for many purposes in marine engineering is thus produced.

(11) *Mechanical Properties of Steel.* The tensile strength of the lowest carbon steel, say about .10 of one per cent carbon, is usually not above from 50,000 to 55,000 lb. per square inch of section. The strength increases with the increase of carbon, and with not above the usual proportions of sulphur and phosphorus, quite uniformly. Experiment shows that under these circumstances the strength will increase up to 75,000 lb. per square inch, or higher, at the rate of from 1,200 to 1,500 lb. per .01 of one per cent of carbon added. At the same time, with the increase in strength the ductility decreases, so that a proper choice must be made according to the particular uses for which the steel is intended. With the best grades of tool steel with carbon ranging from 1-2 to 1 per cent and over, the strength ranges from 80,000 lb. upward to 120,000 lb., and even higher in exceptional cases.

Flange and *rivet steel* must be tough and ductile in the highest degree. Such steel has usually a tensile strength between 50,000 and 60,000 lb. and an elastic limit of 30,000 to 40,000 lb. Its elongation in 8 in. is from 30 to 35 per cent, and reduction of area at the ruptured section from 50 to 60 per cent. It will bend cold on itself and close down flat under hammer or press, up to a thickness of 3-4 in. to 1 in. without a sign of fracture.

Shell steel, used for boiler shells, etc., has usually a strength between 55,000 and 65,000 lb.; elastic limit from 33,000 to 45,000 lb.; elongation in 8 in. of 25 to 30 per cent, and reduction of area of 50 to 60 per cent.

For shafting the quality of the steel is about the same as for shell plates. For piston and connecting rods the strength is rather higher, and ductility somewhat lower.

For steel castings the strength required is usually from 60,000 to 65,000 lb., with an elongation in 8 in. of from 10 to 15 per cent.

Notes of Interest.

Contracts are reported definitely closed for the construction of the two new steamships for the Pacific Mail line, which are to be built at Newport News, Va. The dimensions given are: Length, 550 ft.; beam, 63 ft.; depth, 40 ft. A sea speed of 18 knots is figured on.

The International Steam Pump Company has been organized in the State of New Jersey and includes most of the leading pump manufacturers of the country. The new company has a capital of $27,500,000, with preferred stock amounting to $12,500,000 and $15,000,000 common stock. Many of the concerns in this combine manufacture pumps for marine uses.

Major H. M. Adams, U. S. Engineers, has received the approval of the Secretary of War to his specifications for contracts for improving the East Channel and the Bay Ridge and Red Hook Channels in New York Harbor, under the River and Harbor act. Major Adams will advertise for bids thirty days, and if contractors do not bid for excavating the 39,000,000 cu. yd. at ten cents per yard the Government will build its own plant. The contractor will have one year less one day after signing his contract to begin work.

The appreciation of the nation, expressed through Congress, of the services rendered to his country by George Dewey, U. S. N., was fitly shown by his promotion to the rank of Admiral. This is a rare distinction in the Naval service, the rank having been conferred previously on two occasions only in the history of the United States. By his promotion Admiral Dewey becomes the ranking military officer of the entire Government service, and the date of his retirement is left to be fixed by him whenever he chooses. When the nomination was made and confirmed Secretary Long cabled authority to Admiral Dewey to hoist the flag of an Admiral and to wear the uniform of his new rank. He is hereafter entitled to a salute of seventeen guns.

The Personnel bill, readjusting the rank of officers of the Staff corps and abolishing the Engineer corps of the Navy by amalgamating it with the Line, was passed by Congress before it adjourned early last month. The naval authorities are now at work on the rearrangement of the Navy list in accordance with the provisions of the new law. The changes made by this law in the naval organization are very radical, and among these is one permitting seamen to attain commissioned rank under certain circumstances. A new class of warrant officers, to be known as Warrant Machinists, has been created. In a future issue we shall discuss this most important act.

ELECTRICITY ON BOARD SHIP—PRINCIPLES AND PRACTICE—XVII.

BY WM. BAXTER, JR.

Circuit Breakers.

A circuit breaker is a device which is so arranged that it breaks, or opens, the circuit when the current flowing therein reaches a strength at which the apparatus is set to operate; in other words, the action is controlled by the strength of the current. An electric current flowing in any circuit generates heat therein, and the stronger the current the more heat; therefore, if the strength is allowed to increase without limit, a point is soon reached where the amount of heat gener-

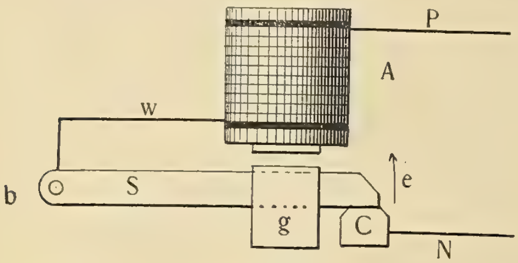


FIG. 94.

ated is more than the wire can get rid of by radiation, and as a consequence the temperature rises to a destructive point. A circuit breaker, therefore, is a protective device whose object is to open the circuit before the temperature reaches a dangerous degree.

A circuit breaker in its most elementary form is illustrated in Fig. 94. In this diagram *A* represents an electro magnet, the ends of the wire coil wound upon it being connected with the wires *P* and *w*. The lever *S* is a switch which closes the circuit between the end of wire *w* and the contact *c* which forms the terminal of wire *N*. The square, marked *g*, is a weight made of iron, and it acts normally to hold *S* down upon *c*. The magnet *A* being energized by the current passing through the coil wound upon it, will exert a small pull upon *g* when the current is weak, but this pull will increase as the current strength increases. If we assume the current to increase continually, it is evident that after a while it will become so strong that the pull of the magnet will be sufficient to lift *g*, and when this

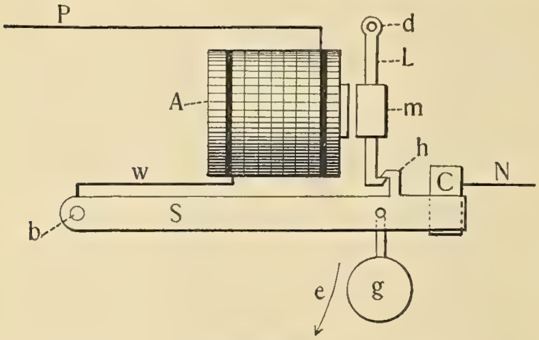


FIG. 95.

action takes place the circuit between *P* and *N* will be interrupted at the junction of *c* and the end of *S*.

This simple device is a perfect circuit breaker and will be very sensitive in its action if the pivot at *b* upon which *S* swings is made as nearly frictionless as possible. It would not be suited, however, to circuits carrying strong currents, as the separation between *c* and *S* is small, being limited by the distance between the top of *g* and the end of the magnet *A*. While a weak current could not jump across the space between the end of *S* and top of *c* when *S* is raised to its highest point, a strong one could; hence, to make a circuit breaker that would be serviceable for the latter purpose it would be necessary to devise a construction that would permit *S* to move much farther away from *c* when moved by the force of the magnet. This result can be accomplished by the construction shown in Fig. 95. In this figure it will be seen that *S* is held in

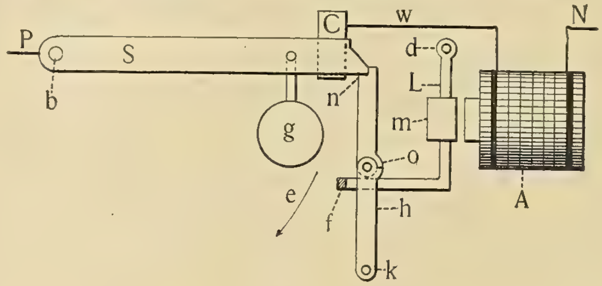


FIG. 96.

place by the hook *h* which engages with a similar hook upon the end of the lever *L*, the latter being pivoted at *d* so as to swing freely in a horizontal direction. The block *m* is made of iron, so that it may be attracted by the magnet *A*. When the current becomes sufficiently strong to cause *A* to act, *L* swings from under hook *h* and then *S* swings in the direction of arrow *e*, and thus

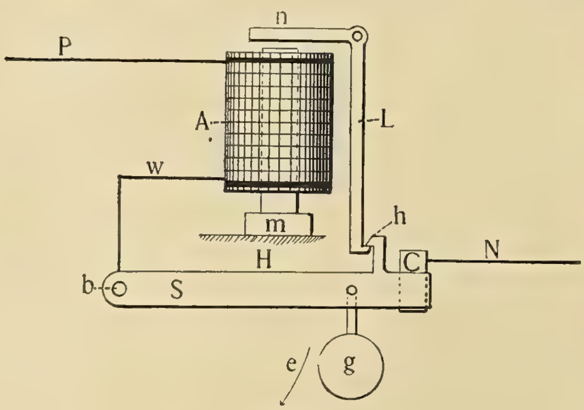


FIG. 97.

the separation between its end and *c* becomes many times as great as in Fig. 94.

It will be noticed at once, that while this construction enables us to obtain as great a separation as may be desired, the action must be very torpid, for the end of *L* must slide from under *h* against the friction produced by the weight of *g* and of *S*. This difficulty we can surmount by adopting the construction shown in Fig. 96. In this diagram it will be seen that *S* is held up by the jointed lever *h*, which is constructed upon

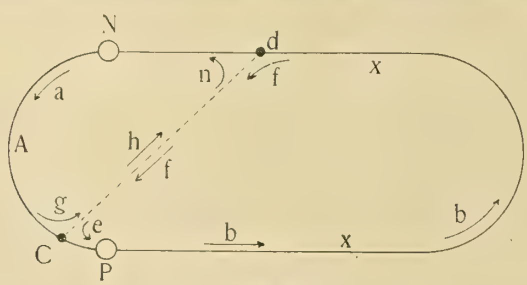


FIG. 98.

the toggle principle, the projections at *o* serving to keep it straight. The block *m* upon the lever *L* is acted upon in the same manner as in Fig. 95, but the end *f* does not have to slide against any frictional force, hence it moves freely and striking *h* throws its center to the right and then the end *n* drops and allows *S* to fall freely.

The diagram Fig. 97 shows another way in which the switch *S* can be held so that the friction of the support may not interfere with its free release. In this arrangement the magnet *A* is of the solenoid type, that is, it consists of a coil of wire with an iron core *m* which fits loosely in the center opening. This core rests upon a suitable support *H*. When the current becomes sufficiently strong, it draws *m* upward, and the velocity with which it is raised is such that its upper end strikes *n* violently, giving it a hammer blow. This blow moves *L* and causes it to disengage from the hook *h*, thus allowing *S* to fall.

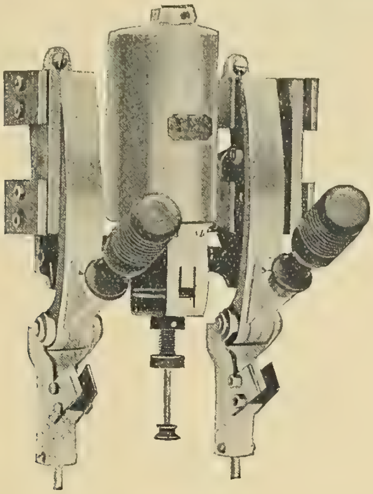


Fig. 99.

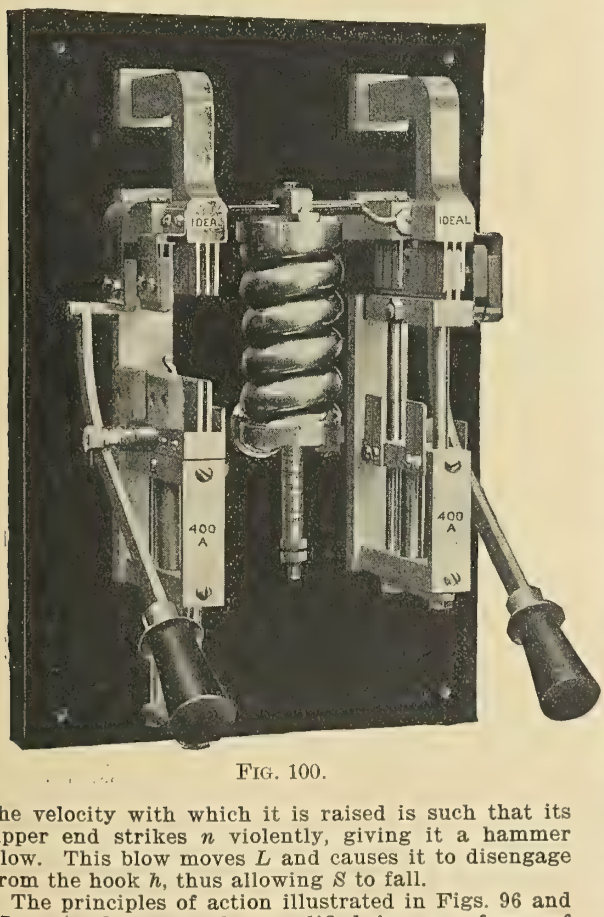


Fig. 100.

The principles of action illustrated in Figs. 96 and 97 are used, more or less modified, in many forms of circuit breakers, while in others different forms of construction are used. As can be readily seen, the object to be accomplished is to get rid of the friction of the construction shown in Fig. 95, and evidently there are many ways in which this may be accomplished.

Circuit breakers, like switches, are classified as single-pole and multipole; of the latter type the two-pole is the only one commonly used. For the protection of a single circuit, a two-pole circuit breaker is in most cases better than the single-pole device, although at a first glance it might appear that a breaker that opens the circuit at one point would be as effective as one that opens it at two, since one interruption in a circuit is sufficient to stop the flow of current. The reason why the two-pole circuit breaker affords greater protection, in most cases, is that if a circuit is grounded, through a defect in the insulation, opening it at a single point may not stop the flow of current in the entire circuit, as through the defect in the insulation a short circuit may be completed. This condition of things can be better explained by the aid of Fig. 98, which is a diagram representing a generator and its external circuit. The left-hand portion of the curve, marked *A*, represents the armature wire, and *X X* represents the external circuit, *N* and *P* being the commutator brushes. The armature is supposed to generate a current in the direction of arrow *a*, and this flows through the external circuit in the direction of arrows *b b*. If there is a defect in the insulation of the armature wire, so that the current can escape to the iron core, no damage will be done if there is no other ground. Suppose the armature defect is at the point *c*, and suppose that another ground is formed in the external circuit at *d*. Now the portion of the armature between *N* and *c* will generate a current that will flow in the direction of arrow *a*, and this when it reaches point *c* will follow arrow *g* and *h* to point *d* and then return to the armature as indicated by arrow *n*. The small portion of the armature from *c* to *P* also tends to generate a current in the direction of arrow *e*, but this current cannot flow through the external circuit in the direction of arrows *b b* unless it can pass from point *d* to *N* direct, for if it should follow the ground path from *d* to *c* in the direction of arrows *f f* it would have to flow against the current coming from the larger half of the armature, and this it could not do. Now suppose we have the circuit protected by a circuit breaker that will open the connection between *N* and *d*, then it is evident that the current generated in the portion of the armature between *N* and *c* will not be able to flow, for it can only pass as far as arrow *n*, since there is a break between *d* and *N*. Thus the circuit breaker placed between *d* and *N* will stop the flow of current through the larger port *o n* of the armature, between *N* and *c*, but as on this account there will be an opposing current flowing between *c* and *d* the current generated in the armature between *c* and *P* will follow the circuit in the direction of arrows *b b* and *f f e*. From this we see that the single circuit breaker placed between *N* and point *d* will not entirely stop the flow of current when the short circuit between *c* and *d* is formed. If, however, we place another circuit breaker next to *P*, then the circuit on both sides of the ground connections *c* and *d* will be broken, and the current will be completely interrupted.

From the foregoing it can be seen that if we desire complete protection it is necessary to use a two-pole circuit breaker, or two single-pole ones. As in diagram Fig. 98 *P* and *N* represent the brushes or binding posts of the generator, they are in reality close together, and can be more easily connected with one double-pole breaker than with two of the single-pole type.

Figs. 99 and 100 show two designs of two-pole circuit breakers that are used extensively. In the first figure both sides of the instrument are shown in the closed position, while in the second the switch on the right side is closed and that on the left is open. The handles are for the purpose of replacing switches when they are thrown open by the action of the current.

ENGINEERS' DICTIONARY—XVI.

Evaporator.—An apparatus for making fresh water to supply the loss in the boiler feed. The usual form of evaporator consists of a series of nests or coils of pipe contained within a chamber as shown in Fig. 66. The chamber contains sea water, and steam from the boilers or from one of the receivers is passed inside the tubes. The heat in the steam passes through the tubes and forms steam or vapor of lower pressure on the salt water side. The chamber is connected with the condenser or with the L. P. receiver, and the steam formed in the evaporator is thus passed into the main circuit and serves to make up the loss of fresh water due to leakage at safety valves, joints, glands, etc., and to loss of steam used in auxiliaries and not returned to the condenser. At the same time the water formed in the coils by the loss of heat is trapped out and returned to the feed, so that there is no expenditure of *steam* by the operation, but only of the *heat* which it carries. The coils on the outer or salt water side become naturally coated with scale, so that they must be cleaned from time to time. To this end they are usually arranged, as shown in the figure, so that they may be readily removed, cleaned, and returned in place.

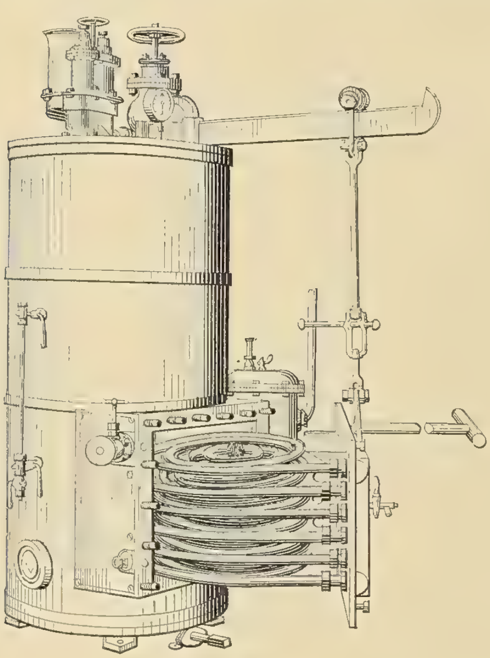


FIG. 66.

Exhaust Cock or Valve.—A cock or valve serving to allow or control the discharge of some liquid, vapor or gas, or its transfer from one receptacle to another.

Exhaust Pipe.—A pipe leading from an exhaust valve for carrying the liquid vapor or gas to the place desired.

Exhaust Lap.—The amount by which a slide valve when in its mid-position covers the port on the exhaust side.

Exhaust Lead.—The amount by which a slide valve port is open on the exhaust side when the engine is at the end of the stroke.

Exhaust Port.—An opening through which air, steam or other vapor is *exhausted* or removed from a cylinder after having completed its work therein.

Exhaust Steam.—Steam which has completed its work in a given cylinder and is passing out through an exhaust port and pipe, either to the air, to the condenser, or to another cylinder. In a multiple-expansion engine the exhaust from one cylinder is the supply for the next beyond, while the final exhaust leads from the low-pressure cylinder to the condenser.

Expansion.—All gases and vapors tend to expand, or to occupy a larger volume. The term *expansion* refers to this general tendency. The expansion of steam or the expansive use of steam refers to the now almost universal mode of using steam, in which after being allowed by the steam valve to enter and fill a portion of the cylinder, the opening for entrance is closed, and the steam thus admitted acts for the remainder of the stroke by its expansive force alone. The *number of expansions* means the ratio between the volume at the end and at the beginning of the expansion; or it is the number by which the original volume of steam is multiplied in the operation of expansion. In modern triple-expansion engines using steam from 150 to 200 lb. pressure, the total number of expansions is usually found between 8 or 9 and 11 or 12. With quadruple-expansion engines and rather higher pressures of steam the number of expansions may rise to 13 or 14 or even higher.

Expansion Gear.—That part of the valve gear which is especially concerned in cutting off the steam and in thus producing its expansion or expansive action. In most modern marine valve gears all separate expansion gear is omitted, and the entire control of the steam is effected by the main valve gear alone.

Expander or Expanding Tool.—A tool for expanding or forcing out the metal of a boiler tube against the metal of the tube sheet, and thus making a steam- and water-tight joint. A common form of expander is shown in Fig 67. It consists of a frame or casing carrying three steel rollers as shown. These rollers instead of running in fixed bearings at the ends are free to move outward or inward in radial slots in the casing. When in use the tool is placed in the end of the tube with the rollers opposite the tube-sheet. A taper steel mandrel is then put in through the central hole between the rollers, forcing them outward against the metal of the tube. This mandrel is then turned by means of a crank or handle attached to the outer end. In this way the mandrel turns between the rollers, while the latter roll between the mandrel and the metal of the tube, thus gradually traveling around the inner surface and rolling the metal outward against the tube sheet. As the operation goes on the mandrel is driven gradually in, thus rolling the metal outward until the desired effect is produced. In the form shown the rollers are placed slightly oblique so that their axes are not quite parallel with that of the tube. In such case when turned in one direction they tend gradually to feed themselves into the tube, and when in the other to back out. In this way the instrument becomes self-feeding, and its entire action is continuous and regular.

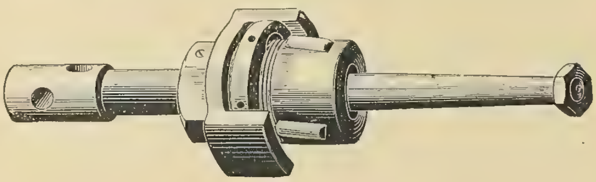


FIG. 67.

Eye-bolt.—See *Bolt.*

Feathering Float.—A paddle-wheel float carried on a form of lever and operated by connection to an eccentric or equivalent device, so that the float shall enter and leave the water in a position nearly or quite vertical. The object of this is to avoid a certain loss due to the obliquity of action in the common form of float. Two forms of mechanism for operating feathering floats are shown in Figs. 68, 69. In Fig. 68 the links similar to *A B* are all pivoted at *A*. This link actuates the lever *B C* and blade *D E* as shown, and similarly for the others. In Fig. 69 *H B* is a drive link actuated by an eccentric with center at *A*. The remainder of the links are pivoted to the eccentric strap as shown, and are connected to blades similar to *D E*,

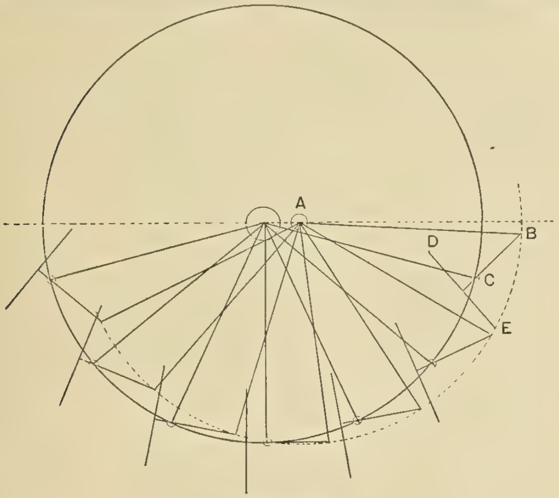


Fig. 68.

as in the diagram. In both diagrams the plane of the blade may be beyond the pivot *C* as shown, or it may

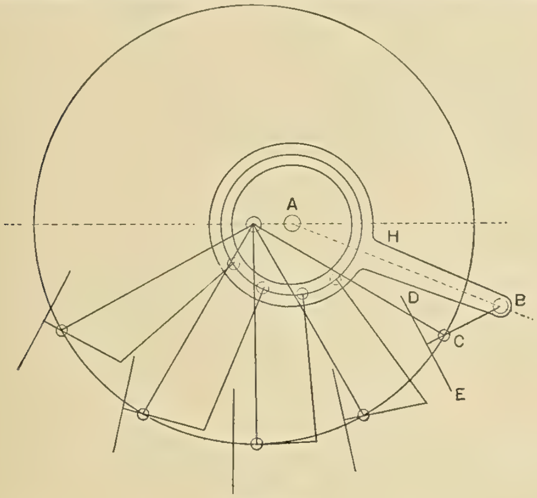


Fig. 69.

contain *C*, or it may lie between *B* and *C*. The arrangement of Fig. 69 is more commonly used, that of Fig. 68 being occasionally employed for small wheels.

Feathering Paddle-wheel.—A paddle-wheel in which the floats are of the *feathering* variety. See above.

With regard to the powering of naval vessels, Engineer-in-Chief George W. Melville, U. S. N., has expressed a preference for triple screws, with three independent sets of engines, the central set to be of greater power than those at the sides. He will read a paper on this subject before the British Institution of Naval Architects in London.

The new Hamburg-American twin-screw passenger and freight steamship Patricia, of the intermediate type, has been launched at Stettin. She is 560 ft. long and 62 ft. beam. The Patricia is about 13,000 tons register. She has a double bottom, extending the whole length of the ship, in twenty-four compartments. The vessel has accommodations for 205 first- and 126 second-class passengers, and 1,000 in the steerage. The cargo capacity is 12,500 tons. She will have a sea speed of about 12 knots.

QUERIES AND ANSWERS.

(Communications intended for this department will not receive attention unless accompanied by the full name and address of the sender, which will be considered confidential.)

Q.—What would you do if the go-ahead eccentric slipped on the shaft? Would it make any difference to the go-ahead motion if the backing eccentric slipped on the shaft? Could either of them be reset correctly without removing the steam chest cover? What effect has linking up on a slide valve? Does it change the throw of the valve? How does it affect the cut-off? Why does an inspirator throw water into a boiler against its own pressure? Mass.

A.—If the go-ahead eccentric slips, the natural remedy is to get it back into place. If it is keyed on the shaft this should not be a difficult job, as the parts of the keyway in the shaft and eccentric will show when they come together that the latter is in the correct position. If the eccentric is secured by set screws, as is occasionally the case, it will probably be necessary to take off the valve chest cover in order to set the eccentric in its exact position.

If the backing eccentric slips, it will make no difference when the link is in full gear; that is, when the motion of the valve is obtained entirely from the go-ahead eccentric. When linked up, however, the valve receives its motion partly from one eccentric and partly from the other, and the slipping of the backing eccentric will introduce more and more disturbance as the gear is linked up farther and farther from the full gear.

With the help of an indicator, yes; without, not very exactly unless the covers were removed. To make a rough setting in a hurry, without removing covers, put the engine on the center and shift the eccentric sheave to about its proper position ahead of the crank in the direction of motion. Put the link in full gear and then open the indicator cocks top and bottom and blow through. If no steam comes out your valve needs a little lead on that end. When you have given this, secure the eccentric, then turn the engine on the opposite center and blow through again. By comparing the amounts of steam passed, you can set the valve so that the engine will work. A leaky piston would give steam at both ends, but you can readily get the required results by observation.

The effects of linking up are as follows: The throw of the eccentric, the travel of the valve and the port opening are decreased. The cut-off is earlier. The lead is increased or decreased or kept constant according to the character and arrangement of the gear. With a Stephenson link fitted with the eccentric rods *open* (not crossed the one over the other when the crank is on the lower center), the lead is increased as the gear is linked up. The exhaust opening is earlier. The exhaust closure is earlier, and the compression is greater.

An inspirator throws water into a boiler against its own pressure for much the same reason that the feed pump forces water into the same boiler, also against its own pressure. In the latter case the total resistance or load on the water plunger is overcome by making the steam piston decidedly the larger of the two. This gives a total push much greater than the total resistance, and the water goes in. The present limits will not allow of a detailed explanation of the operation of an inspirator or injector, and while its operation is quite different in detail from that of the pump, there is yet a broad similarity at the bottom. To put the matter in one sentence, the inspirator forces water into the boiler because the heat energy in the steam used is converted into motion of the jet of feed water and condensed steam, and enough heat is so converted to drive this jet into the boiler against the steady pressure within. There are several good books on the injector in print.

Q.—Please give me a rule for figuring out the strength of a reinforcing ring on a manhole of a boiler. A Subscriber.

A.—There is no regular rule for figuring the dimensions of the reinforcement ring. It is a matter which is determined by experience and practice rather than by mathematics. The ring is usually made of about the same thickness as the shell of the boiler, and should not be less in width than from three to four times the thickness. This will allow sufficient width for a single row of rivets, which should be spaced about the same as for a single riveted lap-joint.

Q.—What is the "equivalent girder?" How is it obtained, and to what use is it applied? CUBITT.

A.—The stress on the structure of a ship at any given cross section is directly proportional to the moment of the external forces about that section, to the distance of the fiber in question from the horizontal gravity axis of the cross-sectional area of the material furnishing longitudinal strength, and inversely to the moment of inertia of the same cross-sectional area about the same axis. The term *equivalent girder* is applied to a method of massing the structural material of the ship in such way that it shall resemble a more or less complicated form of I-beam section. That is, the decks, bottom plating and other horizontal members are massed in horizontal rectangles, while the side plating and other vertical members are massed in vertical rectangles, thus transforming the somewhat irregular structural cross section into a more regular combination of rectangles forming a section consisting of horizontal flanges and vertical webs. The strength of the ship is then considered the same as that of a girder having such a section and subject to the same external forces. From this section we may then determine the moment of inertia referred to above. The formation of this section was thus an intermediate step in the determination of the moment of inertia of the cross section of the structural material, and served further to show to the eye in a general way the manner in which the material was distributed through the cross section.

It may be noted that the construction in this way of an equivalent girder is a wholly unnecessary operation. The method of massing the material is to some extent quite arbitrary, and if measurements to scale are taken directly from the girder section for purposes of computation, the latter will necessarily contain a certain amount of instrumental error. The moment of inertia can be quite as satisfactorily obtained from the scantling cross section itself by taking in order each piece, of area as given by its dimensions, and treating it as a small rectangle of height equal to that which the piece covers. These operations arranged in tabular form furnish an orderly and reliable mode of obtaining the moment of inertia without constructing the equivalent girder as an intermediate step. It is true that the number of items in the computation is greater than with the equivalent girder, but the time required to make the construction and the possibility of error, as before referred to, are avoided. Limits of space prevent a detailed account of the various operations required to carry out this computation, which, of course, involves an extensive use of mathematics.

Q.—Please inform me how to get the tonnage of a launch 50 ft. long, 9 ft. beam and 6 ft. deep; also what is meant by displacement, and how to figure it out. What is the meaning of gross and net tonnage of a boat? W. C.

A.—*Tonnage* refers to the internal capacity or volume of a ship.

Gross Tonnage is the entire internal capacity measured according to certain rules specified according to the size and type of vessel.

Net Tonnage is the remainder after having taken from the gross tonnage certain allowances for crew space, engine and boiler rooms, shaft alley, etc.

Displacement is the weight of the water displaced by the ship, or what is the same thing, the weight of the ship itself and everything on board. Hence displacement varies from day to day, or from one voyage to another, while tonnage, being determined simply by the type and internal dimensions of the ship, is constant. Tonnage is supposed to represent a ship's earning capacity, and hence it usually serves as the basis for port and navigation charges. Tonnage cannot be found without taking actual measurements from the ship itself. The rules will be found among the navigation laws of the United States, or see Revised Statutes, Chap. 1, Title XLVIII, Sections 4150 to 4153, and Chap. 398.

Q.—What are the advantages of a compound engine over a simple engine? C. H. L.

A.—The chief advantage of the compound over the simple engine is in its greater economy. Other things being the same, it requires less coal to develop a horse power with a compound than with a simple engine. A large part of the loss in the steam engine is due to the condensation of steam on the internal surfaces of the cylinder, cylinder head and piston, during the admission period. This loss in the compound is only about one-half what it is in the simple engine, and there is a corresponding gain in economy. In a still more marked degree this loss is cut down by the triple- and quadruple-expansion engines. Where a simple engine will give a horse power for from 3 to 3 1-2 lb. of coal we may expect that a compound will give the same power for from 2 to 2 1-2 lb., a triple for 1.8 lb. or less, and a quadruple for 1.5 lb. or less. The detailed explanation of the causes of this gain would occupy more space than we can give here.

Another point which may be mentioned is that the compound marine engine has usually two cranks and gives therefore a more uniform turning effort on the shaft than a single engine. This result might, however, be attained by the use of two simple engines, so that it is not a necessary advantage of the compound system, but rather a result which naturally goes with that type. With the triple- and quadruple-expansion engines the crank effort is similarly made still more uniform, by the additional cranks distributed uniformly around the circle.

Q.—Given length, beam and draught of hull, and diameter, pitch and revolutions per minute of propeller, how can the approximate speed of a vessel be determined? What is the usual pitch of propellers for launches, both solid and reversible? DUNRAVEN.

A.—The speed of a ship depends on her length, beam, draught and form, together with the I. H. P. and propeller efficiency. You do not refer to the I. H. P. in your question, though it is naturally one of the fundamental quantities upon which the speed depends. So far as the dimensions of the propeller are concerned, and assuming that it is working at a fair efficiency and an apparent slip of 15 to 25 per cent, an approximate value of the speed would be found by multiplying pitch by revolutions, the product by (1 — slip ratio), and reducing the result to miles per hour by dividing by 88, or to knots by dividing by 101.3. Thus with pitch 3 ft., revolutions 300 and slip .20, the speed would be given in miles by:

$$V = (300 \times 3 \times .80) \div 88 = 8.18.$$

There is no possible answer to your last question regarding the usual pitch of launch propellers. From 18 in. to 5 ft. will cover the usual range of values.

Q.—What would be the proper amount of lead for a slide valve on a steeple compound 24 in. and 42 in. by 30 in. engine used in a tug for heavy towing and turning about 84 revolutions per minute? H. D. W.

A.—The information you give is insufficient as you say nothing about the valves, size of ports, etc. As a guess we would say that 1-8 in. lead would probably be correct in the case you mention.

Obituary.

Chief Engineer Robert R. Leitch, U. S. N., retired, died on March 14 at the Brooklyn Hospital after an operation for appendicitis. He had been ill but four days. Mr. Leitch was forty-nine years old. He was graduated from Annapolis in the class of '71 and stood at its head. He was appointed Second Assistant Engineer in January, 1874, Assistant Engineer in February, 1874; Passed Assistant in January, 1879, and Chief Engineer in September, 1894. He was retired in 1896 on account of ill health. At the beginning of the war he re-entered active service and was assigned to duty at the Pensacola Navy Yard. He leaves a widow. The interment took place in Baltimore, the birthplace of the deceased.

Assistant Naval Constructor Robert Dashiell died in Washington, D. C., March 8 of cerebro-spinal meningitis, after being ill three days. He leaves a widow and three young children. Mr. Dashiell, who was graduated from the Naval Academy in 1884, was an ordnance expert, and also an authority on the subject of docks.

In these days of foreign service the constant transfer and change of residence of officers of both the Army and Navy makes it difficult for persons interested to follow their movements. Of great assistance in this respect are the lists published in the *Army and Navy Journal* of New York each week. They are manifestly prepared with great care and are the most complete in periodical form.

RECENT PUBLICATIONS.

La Guerra del 190— (The War of 190—). Lega Navale, Spezia, Italy. Size, 8 by 11. Pages, 75. With many illustrations. Paper covers.

This little book adds another to the list of imaginary wars written usually for the purpose of impressing upon some people or government the need of a more active military or naval policy. In the present case Italy and France are the combatants, and the book is written from the Italian standpoint in order to show the need of a more powerful navy if Italy is to hold the place among her neighbors which is her due. The cause of the war is simple and is readily found. The *Triple Alliance* is supposed to have been sometime broken, and Italy is left without formal ally. An aggressive French colonial policy and a restriction of the rights of Italians in French colonies leads to strained diplomatic relations between the two countries. Soon a collision occurs on the frontier and by natural steps, in which modern sensational journalism takes no small part, the situation results in a declaration of war. The story of the war itself is told in a series of letters between the captain of the Italian flagship *Benedetto Brin*, his wife, his nephew, who is an officer of the general military staff, a friend who is captain of the Italian battleship *St. Bon*, and a friend who is a member of the Chamber of Deputies. By this means descriptions are given of the chief events, including an attack on Spezia, the bombardment of Genoa and Naples, the attack of the Italians on Biserta, where the exit of French war and merchant ships is prevented by sinking in the channel a large French liner, the *St. Jacques*, recently captured by a torpedo-boat destroyer, after the manner of the *Merrimac* at Santiago. The chief naval battle is that of Cape Caccia, in which the Italians are successful, but at severe loss. This is followed by final disaster at the hands of the French northern fleet hitherto held in reserve. Questions of tactics, of naval discipline and of the relations between the naval and legislative powers of a government are discussed in a familiar and pleasant manner, while the purpose of arousing Italy to the necessity of a more vigorous naval policy is kept clearly to the front. Copious illustrations are given of leading ships in both the French and Italian navies.

"The Practice and Theory of the Injector," by Strickland L. Kneass, C. E., is without doubt the most comprehensive and practical treatise on the subject, and we are glad to note the publication of a second edition, with additions and revisions to date. In this book, while the history and theory of the instrument receive ample attention, it is written from the standpoint of the "practical man" in full and complete touch with his subject rather than from the standpoint of the theorist. In the treatment of the subject after developing the principles involved and pointing out the essential elements of the apparatus, the author dissects it, taking up the various tubes and studying their functions separately and in detail. This leads to a consideration of the injector as a whole, and then there are also notes on the selection, the determination of size, and matters of repair. The suggestions for determining the causes of failure are sufficiently explicit to enable any one with ordinary mechanical skill to diagnose any common ailment and to apply the proper remedy. In fact there is little that the working engineer desires to know about the injector that cannot be found in this book. It contains 158 pages, with many engravings and drawings, and is published by John Wiley & Sons, New York; price, $1.50.

The name of President Hill, of the Great Northern Railway, has been associated with a project to establish a new line of steamships to trade between Seattle, Yokohama, Hong Kong and Vladivostock.

TRADE PUBLICATIONS.

A neat folder, on the front of which is a fine cut of the yacht Susanne, is issued by Wilson & Silsby, announcing the removal of their lofts to new quarters especially prepared for them in the north side of Rowe's Wharf, Boston, Mass.

A pocket size slip, upon which is printed a large picture of a compound engine, is sent to all users who are interested in the marine engine, by Nelson W. Twiss, New Haven, Conn. The cut gives a very good idea of the general construction of the Twiss engine.

"Incrustation and Corrosion" is the title on a pocket size paper bound book issued by the Pittsburg Boiler Scale Resolvent Co., Pittsburg, Pa. Those of our readers who have any trouble with boilers and who are interested in the subject of scale and corrosion will find a copy interesting reading.

"Mechanical Draft" is the subject treated in a very neatly printed 8-page pamphlet in two colors, issued by the Sturtevant Co., Jamaica Plain, Mass. Although the matter is stationary rather than marine, it will still be of much interest to many of our readers. Copies can be had by applying for them.

"Electric Welding" is the title of a very neat catalogue printed in two colors and sent to all inquirers by the Standard Tool Co., Cleveland, O. The paper cover is finely illuminated in silver and printed in red and dark green. The book is devoted very largely to describing samples of welding which are illustrated with much taste.

"The Teachers' Note Book," just issued by the Joseph Dixon Crucible Co., Jersey City, N. J., should be in the hands of every reader who wishes to enjoy a good laugh and at the same time have at hand important information regarding lead pencils. The subject matter is very skilfully put together and will interest every person who uses a lead pencil.

"Facts on Boilers" will be sent by the Sumac Co., Ltd., Wilder Building, Rochester, N. Y., to all inquirers who are interested in the subject of the care of boilers. This folder gives information regarding the cause of boiler explosions and other troubles, and tells in a few words what the Sumac boiler compound is and what it is designed to do.

A circular is received regarding the new gasoline engine which is being put on the market by Thomas P. Benton & Son, LaCrosse, Wis. This engine is of the vertical two-cycle type, and is fully illustrated, the several illustrations showing the engine from the smallest size up to 40 horse power. Further information can be had by writing for copies of these circulars.

Bundy steam specialties receive much attention in a 40-page catalogue just issued by the manufacturers, A. A. Griffing Iron Co., Jersey City, N. J. These specialties include return steam traps, steam and oil separators, separating steam traps, etc. The catalogue is neatly printed on good paper and the several devices fully illustrated, giving altogether as much information as could well be asked for.

"A Bird's Eye View of Our Business" refers to the Westinghouse Machine Co., Pittsburg, Pa., which is an unusually neat pamphlet printed in two colors and devoted to the Westinghouse engines. The several types and styles of engines are particularly well shown by fine half-tone engravings. These include several direct connected electric plants, which will be of much interest to many of our readers who have to do with electric lighting on board ship or in the shipyard. A good deal of information is given regarding the Westinghouse gas engine; also regarding the refrigerating process. Copies of this book should be in the hands of all of our readers, and may be obtained from the Pittsburg office or from Westinghouse, Church, Kerr & Co., 26 Cortlandt street, New York.

"Vessels Owned on the Pacific Coast and Hawaiian Islands" is the title of an 80-page paper bound book, 6 by 9 in. in size, issued by the Commercial Publishing Co., 34 California street, San Francisco, Cal. Many of our advertisers and readers who wish to send out circulars, or for other purposes wish to reach shipping people on the Pacific coast, will find this book of much value, as it gives a complete list of vessels documented at San Francisco, Puget Sound ports and all other ports on the Pacific coast of this country; also in Honolulu, the list being compiled from official sources. The price is only 25 cents. Copies can be had from the Commercial Publishing Co.

"Architects' and Engineers' Electrical Bulletin for February" is a very handsome publication issued by the Sprague Electric Co., 20 Broad street, New York. It comprises about 75 pages, 9 by 12 in. in size, bound in very handsome green paper cover which is printed in dark red and gold. The table of contents is varied and contains much valuable information, such as electricity as applied to automobile carriages, electric railways, electric heating, the running of exhaust fans, together with information on wiring practice, electric motors, generators, etc. Copies will undoubtedly be sent to all of our readers who write and mention Marine Engineering.

Graphite paint is very thoroughly discussed in a catalogue of 106 pages, 6 by 9 in. in size, and very handsomely printed on coated paper, issued by the Detroit Graphite Mfg. Co., Detroit, Mich. A good deal of information is given regarding graphite and the manner of preparing it for paint, and there is much detailed information regarding the subject of paint, especially that made from this mineral. About seventy-five pages of the catalogue contain large pictures of battleships, lake and other vessels, bridges and prominent buildings where paints and other graphite products of the Detroit company have been used. The first picture is a large and very handsome one of the Waldorf-Astoria hotel. Our readers will find this catalogue worth sending for.

"The Test of Time" is the title of a very handsomely published and illustrated catalogue of 64 pages, the fourth edition of which has just been issued by Ostermoor & Co., 116 Elizabeth street, New York. It contains a great deal of information regarding the patent elastic felt mattresses manufactured by this company. Many illustrations show the different styles of mattresses; also pillows in many forms and shapes. Many testimonials from yachtsmen and others are given, and there is much information regarding the life-saving mattresses which this company manufactures. The mattresses are used in the Light House, Life Saving, Coast Survey and many other departments of the Government, as well as on many coast lines of steamships, lake steamers, Hudson river boat lines, etc. Particular attention is also given to a description of cushions and upholstery for yachts, a special advantage being that they can be used as life preservers. Copies of the catalogue can be had from the company by mentioning Marine Engineering.

The advantages of the Mississippi safety water-tube boiler are set forth in much detail in a catalogue just issue by the Mississippi Safety Water-Tube Boiler Co., 904 Olive street, St. Louis, Mo. This is one of the recent boilers in the marine field, and special attention is given in this catalogue to the question of circulation, dry steam, accessibility for repairs, economy, light weight, etc. A number of pictures tell plainly the general construction of this boiler.

"Hardening for Business and Hard Facts" is the title of a pocket sized pamphlet issued by Loring, Coes & Co., Worcester, Mass. It is devoted especially to the pyro-calcic hardening and annealing process adopted by this firm. The pamphlet is very neatly illustrated and printed in two colors. The text gives a good deal of information regarding the hardening process and the results obtained. This process can be applied to special tools and to almost any kind of metal.

"Pantasote," stamped in gilt on a Pantasote bound pamphlet, is descriptive of the peculiar quality of this material. Pantasote is especially adapted for upholstering cushions and furnishings on board yachts and ships and for a great many other purposes, including the binding of books and other uses which are told of in this pamphlet, which is lithographed in three colors. Copies of this pamphlet and more detail regarding the material can be had from the Pantasote Co., 29 Broadway, New York.

Yachtsmen and others interested in the subject of an engine that is simple and easily handled will want to send for a catalogue of the Knickerbocker, manufactured by the Knickerbocker Engine Works, Hartford, Conn. This engine is made either simple or compound, as described and fully illustrated in the catalogue, and needs no more attention than to see that oil is in the oil cup when the engine is started. As shown in the advertisement of this company, the engine is controlled entirely by a lever in the pilot house.

"Steel Plate Fans" is the title of a catalogue of 132 pages, of which the B. F. Sturtevant Co., Jamaica Plain, Mass., has found it necessary to issue a second edition. As its title indicates, the catalogue is devoted to the subject of fans, and all kinds of blowers are shown in these pages, with many diagrams and tables regarding capacity, etc. The subject matter will interest many of our readers who are interested in the subject of mechanical draft or the ventilation of holds or buildings.

"The Bullard Book" is a beautifully printed 7 by 10 in. catalogue devoted to machine tools manufactured by the Bullard Machine Tool Co., Bridgeport, Conn. The printing and engraving are of the very highest quality. The subject matter is in two colors, and the book is bound with a silk cord, with a handsome cover printed in two colors. Any one of our readers who is at all interested in boring and turning mills should have a copy for reference, as illustrations and descriptions are given of about a dozen types and sizes of these mills, together with other information regarding them.

Two catalogues are received from the International Correspondence Schools, Scranton, Pa. One, entitled "Your Chance Has Come," tells of the training that a number of men have secured through this school in mechanical draughting so as to secure better positions for them or bring increased salaries in their present positions. The subjest of mechanical drawing is one that will interest many of our readers, and undoubtedly those who are seeking information in this line may know some of the men this catalogue speaks about. The other catalogue gives a brief description of short courses in these schools in mechanical and ornamental drawing, bookkeeping, stenography, etc.

The death is announced of Edward Smith Taber, president and treasurer of the Morse Twist Drill & Machine Co., New Bedford, Mass., since 1868, at the age of 73 years. Mr. Taber's business career and that of this company are practically identical, and no greater tribute to his business ability could be paid than the simple announcement that his business grew from small proportions to one of the greatest and most widely known of its kind, not only in this country, but abroad. Mr. Taber was not merely a figurehead, but took active part in the business of the company. As a representative business man, Mr. Taber was also connected with several of the leading financial and other institutions of New Bedford. His death will be widely regretted by a long circle of business associates and friends.

BUSINESS NOTES.

Electrical Exhibition.—An electrical exhibition is to be held in Madison Square Garden, New York, from May 8 to June 3. Many of our readers who have mechanical devices in any way adapted to electrical work and wishing to make exhibition should apply to Marcus Nathan, at the Garden building.

A New Launch Concern.—The Western Gas Engine Works, which formerly had a small plant in Grand Rapids, Mich., have removed to Mishawaka, Ind., and established a large plant, where not only gas engines will be built but a full line of yachts and launches can be supplied. This concern will make a specialty of a 16-ft. launch which will be within the reach of all so far as price is concerned.

The Deane Pumps.—The Deane Steam Pump Co., Holyoke, Mass., reports many orders lately for pumps of various kinds, among such being orders for two large vertical ballast pumps for the new steamer which the Union Dry Dock Co., Buffalo, N. Y., has on the ways. The Deane company also received the order for the outfit of pumps for two large steamers which are being built for the North German Lloyd Co., at Bremen, Germany. This order includes horizontal, duplex, bilge, feed and vertical ballast pumps.

Monitor Vapor Engines and Launches.—C. B. Sterling & Co., 120 Liberty street, New York, have made arrangements to represent the Monitor Vapor Engine Co. This concern has an exhibit in its office of a Monitor engine and now has an order on hand for a 40-ft. launch which will be fitted with a 16-horse-power mogul engine. Catalogues and other information sent to all inquirers.

Artistic Brass Work.—J. J. Ryan & Co., 68-74 West Monroe street, Chicago, Ill., who claim to be the largest jobbing brass founders in the country, and who also manufacture a line of babbitt metals in addition to a full line of brass and bronze work for marine purposes, have just completed a very effective medallion and series of panels in bronze to be placed on a monument in Kansas. This order shows the scope of the work which this firm undertakes.

The Bachelder Indicator.—Attention is called to the advertisement of Richard Thompson & Co., 120 Liberty street, New York, who sell the Bachelder adjustable spring indicator, which, with the Ideal reducing wheel, makes a complete indicator outfit. This was first brought out about eight years ago by Mr. Thompson, and has lately been fitted with all the latest improvements, parallel motion, drum spring, etc. Full information can be had by writing.

Cold Galvanizing Process.—We are informed that the Standard Oil Co. has adopted a cold process for galvanizing in its works at Bayonne, N. J., replacing the old style of doing this work. This indorsement of the cold process is very gratifying to the owners of the process, the U. S. Electro-Galvanizing Co., 346 Broadway, New York. This company is now selling rights to introduce the system. Full information can be had regarding it by writing to the company.

To Fill up Checks.—A composition designed especially for filling up and smoothing over checks and cracks in masts, booms and other wood work is offered by Cole & Kuhls, foot of Twenty-fourth street, Brooklyn, N. Y. This composition has been used on many of the best-known yachts and vessels in the country, and the fact that duplicate orders have been received in many instances is significant. This composition is not affected by temperature, as it shrinks and expands with the wood. Any one interested in the subject can secure full information, with sample enough for a test, by writing to the manufacturers.

Sheaves with Metaline Bushings.—The Boston & Lockport Block Co., Boston, Mass., informs us that it has been compelled to make a large addition to its plant in East Boston, both in building and machinery. This enables the company to carry a larger stock, and to execute orders for special blocks with greater facility than before. The coming year will be the twenty-fifth anniversary of the introduction of the celebrated metaline bushings into block sheaves, shown in the advertisement elsewhere. As business improves the company notes a change from the cheaper class of blocks to a better class, which seems to be encouraging, since any attempt to reduce the standard strength and quality of such an article as a block ought never to have favorable consideration.

Marine Engines.—Attention is called to the advertisement of the Morris Machine Works, Baldwinsville, N. Y., which build a line of high-speed simple and compound engines from three-horse-power upward. The intention of the builders is to secure a staunch engine and at a price within the reach of all. This concern also makes a full line of centrifugal pumps for all purposes. Many pumps of this make are used in the U. S. Navy.

A Busy Shop.—The Columbia Engineering Works, Imlay and William streets, Brooklyn, N. Y., report the past year as one of the busiest ones in the history of the establishment. This company thoroughly overhauled the U. S. army transport Berlin, and did a great deal of work on the Mississippi. One of the latest jobs was extensive repairing to the S.S. Catania. This comprised overhauling machinery and boilers, fitting on new funnels and doing other work. This establishment also fitted the Munson liner Ardanmhor for a cattle ship, and is overhauling the tramp steamships Thomas Mellville, Lauenberg and Birchtor.

A New Metal Polish.—A new metal polish is offered to the public by the Alco Vapor Engine Co., Jersey City, N. J. This polish leaves an oily finish on whatever metal it is applied to, protecting it from the action of salt water.

The Indicator.—Almost every marine engineer knows the value of an indicator and will appreciate the many new features which have been adopted in the Robertson-Thompson indicator, manufactured by James L. Robertson & Son, 218 Fulton street, New York. This firm is always ready to interest inquirers and give information relating to these indicators.

A Large Launch with Gas Engine.—The Racine Yacht & Boat Works, Racine Junction, Wis., has nearly completed a 47-ft. launch for Quebec parties which is designed to make 12 1-2 miles an hour. It is equipped with a 20-horse-power gas engine, and will have a 32-in. wheel. Besides large launches with gas engines this company makes a specialty of everything in the way of boats or launches.

PUMPS FOR THE "MAINE."—In addition to the order for pumps for the Russian war vessels which the Cramp Shipbuilding Co. recently placed, the Snow Steam Pump Works, Buffalo, N. Y., have received the order for an outfit of pumps for the battleship "Maine." These include pumps for all the various uses on the ship.

MACHINE TOOLS.—A full line of machine tools for both wood and metal working is offered for sale and is always on exhibition by J. W. Cregar in the machinery department of The Bourse, Philadelphia, Pa. This is a special machinery sales agency, and includes the tools of most of the leading builders of the country. Mr. Cregar can supply a complete outfit of tools, from a small repair shop on board a ship to the equipment of a large shipyard.

NON-MAGNETIC WATCHES.—Every engineer will appreciate the possibility of damage to a high-grade watch on board ship or elsewhere where electricity is used, and will, therefore, be interested in the non-magnetic watches offered by A. C. Becken, 103 State street, Chicago, Ill. These watches are not only so constructed that they cannot be affected by electricity, but they are "adjusted" to temperature and have many other of the special features of the high-grade watches. They are sold at a very moderate price. Circulars and full information regarding them can be had by writing to the manufacturer and mentioning Marine Engineering.

THE TAYLOR WATER-TUBE BOILER.—The late owner of the yacht Azalea, in a letter to the Detroit Screw Works, Detroit, Mich., refers to a "brush" with the fast steamer Frank E. Kirby, and said: "The fact is that we just played with the 'Kirby' all the way from Put-in-Bay. To judge from the rapid way in which we left her on the 'homestretch,' my opinion is that we can beat her at any time, barring accidents, and the way the Taylor boiler steamed when we put the blower on full was a caution."

BETHLEHEM AS AN INDUSTRIAL CENTER.—The Board of Trade of Bethlehem, Pa., is making a most commendable effort to direct attention to that city as a site for industrial works, where metal working especially can be carried on to much advantage. The place is already well known as the home of the great Bethlehem Iron Works, where so many beam forgings have been made for war and merchant vessels. Manufacturers interested in this subject should write to A. C. Graham, Secretary of the Board of Trade, South Bethlehem, Pa., who can give information.

SPECIAL NOTICES.

Announcements under this heading will be inserted at the uniform rate of thirty-three-and-a-third cents a line. Lines average ten words each.

RAINBOW PACKING

Makes a Steam Joint Instantly.

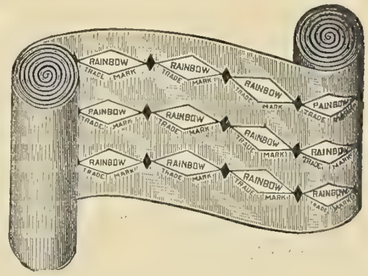
HONEST JOHN.

MR. JOHN H. DEMING,
General Superintendent Peerless Rubber Manufacturing Co.

THE COLOR OF RAINBOW IS RED.

NOT AFFECTED BY OILS, AMMONIA LIQUORS, STEAM HEAT OR ALKALIES.

None genuine without the Trade-Mark.



RAINBOW PACKING HAS 3 ROWS OF DIAMONDS IN BLACK EXTENDING THROUGHOUT THE ENTIRE LENGTH OF EACH AND EVERY ROLL.

Fac-simile of a Roll of Rainbow Packing.

Who invented and who is the only man in the world who can make or ever has made

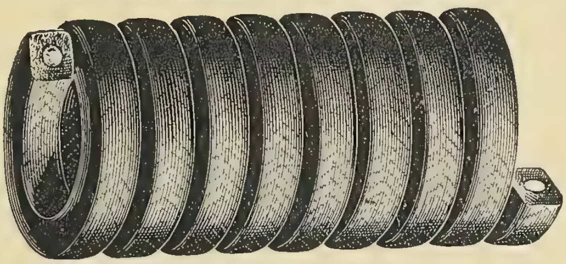
Rainbow Packing.

RAINBOW GASKETS are especially adapted for Low Pressure Steam and Hot Water Heating Apparatus.

PEERLESS DISCS for Russell, Frink, Walworth, Jenkins, Lorain and Kelly & Jones Valves.

"HONEST JOHN."

Made in both Straight and Spiral Form.



Once Tried, Always Used.

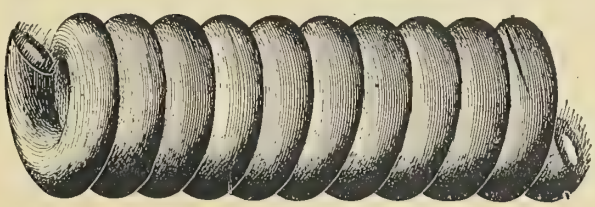
Put up in Boxes

HYDRAULIC RAINBOW CORE PACKING.

THE BEST HYDRAULIC AND COLD WATER PACKING IN THE WORLD.

Hercules Combination.

Always Tight. Leaves the Stem Clean.



Will Hold 400 lbs. Steam.

Metallic Stop Valve Packing.

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THE PEERLESS RUBBER MANUFACTURING CO.,

16 Warren Street, New York.

16-24 Woodward Ave., Detroit, Mich. 202-210 So. Water St., Chicago, Ill.

17-19 Beale St., and 18-24 Main St., San Francisco, California.

CIRCULATORS NOW IN USE IN 87 BOILERS.

Name of STEAMER	No. of Boilers	ROUTE.	OWNERS.	BUILDERS.
City of Chester	2	Wilmington, Phila.	Wilmington Steam Boat Co.	Harlan & Hollingsworth Company
Brandywine	2	" "	" " " "	" " " "
Al Foster	2	New York Fishing Banks	Al Foster Steam Boat Co.	" " " "
Richard Peck	6	" " New Haven	New Haven Line	" " " "
Mauchunk Ferry	2	" " Jersey City	N. J. Central R. R. Co.	" " " "
Easton Ferry	2	" " " "	" " " "	" " " "
Au Revoir	2	Steam Yacht	Wm. I. Du Pont	" " " "
Glouster S. S.	4	U. S. Transport	Merchants' & Miners' Tr. Co.	Maryland Steel Company
City of Lowell	6	New York, New London	Norwich Line	Bath Iron Works
Supply S. S.	1	U. S. Provision Ship	United States	Wm. Cramp & Sons
Southwark S. S.	3	New York, Southampton	American Line	Denny Bros., Dunbarton, Scot.
Yale S. S.	9	U. S. Auxiliary Cruiser	" "	J. & G. Thomson, Clydebank, Scot.
Howard	4	U. S. Transport	Merchants' & Miners' Tr. Co.	Harlan & Hollingsworth Company
Susquehanna	1	Steam Yacht	Jos. Stickney	" " " "
Pennsylvania S. S.	1	U. S. Transport	American Line	Wm. Cramp & Sons Co.
New York	2	Pilot Boat	New York Pilots	Harlan & Hollingsworth Company
Bluefields S. S.	1	Baltimore, New York	Shriver Line	E. J. Codd & Co., Baltimore.
Juniata S. S.	4	U. S. Transport	Merchants' & Miners' Tr. Co.	Harlan & Hollingsworth Company
Ericsson	1	Baltimore, Philadelphia	Ericsson Line	Neafie & Levy Co.
Niagara	3	Steam Yacht	Howard Gould	Harlan & Hollingsworth Company
Transfer No. 11	1	Tug, New York	N.Y., N. H. & Hartford R. R.	Pusey & Jones Co
" " 12	1	" "	" " " "	" " "
S. T. Morgan S. S.	2	Freight Ship	Chemical Co.	Harlan & Hollingsworth Company
Confidence	1	Tug, Boston	Boston Tow Boat Co.	Campbell & Zell Co.
....	1	Tug, Baltimore	P. Daugherty & Co	" " "
S. S.	4	Baltimore, Boston	Merchants' & Miners' Tr. Co.	Harlan & Hollingsworth Company
S. S. Ajax	2	Oil Tank Str	Standard Oil Co.	Delaware River Iron Shipbuilding Co.
Str. Flyer	1	Seattle, Tacoma	Puget Sound and Columbia River Navigation Company	

63 ANNULAR STEAM JETS NOW IN USE.

Name of STEAMER.	STACK. (Inches.)	ROUTE.	OWNERS.	BUILDERS.
City of Chester	51	Wilmington, Phila.	Wilmington Steam Boat Co.	Harlan & Hollingsworth Company
Brandywine	48	" "	" " " "	" " "
Al Foster	64	New York Fishing Banks.	Al Foster Steam Boat Co.	" " "
City of Lowell	2-84 x 100	New York, New London	Norwich Line	Bath Iron Works
S. S. Fairfax	Donkey 13x33	Baltimore, Boston	Merchants' & Miners' Tr. Co.	Harlan & Hollingsworth Company
Yankee Doodle	....	Pleasure Yacht	McBride Bros.	McBride Bros.
Frederica	25	Philadelphia, Frederica	Frederica Steam Boat Co.	Neafie & Levy Co.
Yacht	15½	Lake Champlain	W. J. McCaffrey	
S. S. Howard	13x33	Baltimore, Boston	Merchants' & Miners' Tr. Co.	Harlan & Hollingsworth Company
Montauk	42	Tug, New York Harbor	Long Island Railroad Co.	Neafie & Levy Co
Hampton Roads	42	Hampton, Norfolk	Old Dominion Steamship Co.	Harlan & Hollingsworth Company
Northampton	42	Norfolk, Gloucester	" " " "	
Hatteras	26	Tug, New York Harbor	" " " "	
Millie K. Ridgeway	29	" Philadelphia		
Middletown	2-48	New York, Hartford	Hartford Steam Boat Co.	Neafie & Levy Co.
Rein a de Los Angelos	2-42	Cuba		" "
Endeavor	26	Philadelphia, Seaford	Denny Bros.	Chas. Hillman & Co.
Margaret	39	Port Tampa, Fla.	Plant Steamship Co.	Newport News Shipbuilding Co.
Donato Guerra	45	Revenue Cutter	Mexican Government	Neafie & Levy Co.
Atlas	48	Tug	Standard Oil Co.	Harlan & Hollingsworth Company
Bay Queen	50	Providence, Fall River & Newport Steam Boat Co.		
Mara	17	Zulia River Lake Maracaibo, Venezuela		Pusey & Jones Co.
R. D. Tisdale	60	Whitehall, Lake Champlain		
Catawissa	36	Tug	Reading Railroad Co.	Harlan & Hollingsworth Company
Plymouth	51	Boston	Winthrop Steam Boat Co.	Neafie & Levy Co
Philadelphia	54	Pilot Boat	Jersey & Delaware Pilots	" "
New York	46	" "	New York Pilots	Harlan & Hollingsworth Company
S. S. Princess Anne	96	New York, Norfolk	Old Dominion Steamship Co.	Dela. River Iron Shipbuilding Co.
Lincoln	78	Boston & Bath, Me.	Kennebec River Line	Bath Iron Works
Juniata S. S.	12x33	Boston, Baltimore	Merchants' & Miners' Tr. Co.	Harlan & Hollingsworth Company

This Circulating Apparatus

Maintains a constant circulation while boiler is being fed, giving temperatures of 270° to 320° at bottom. Preventing leaks, increasing steaming capacity and saving coal and cost of repairs, sufficient to pay for the apparatus in six months. Stops foaming or priming and pitting. The steam heating attachment using steam from donkey boiler will heat the water in main boiler to 200° in half an hour from cold water while fires are being started and be ready for steam in an hour without straining boiler.

The Improved Annular Steam Jet

Very powerful and economical; easily installed; moderate in price; occupies no valuable space and requires no attention. Does not effect the natural draft and is always ready at a moment's notice. Orders filled promptly and on short notice. Satisfaction guaranteed.

SAMUEL SUTTON,

Agent for Pacific Coast,

329 Warren Ave., Seattle, Wash.

H. BLOOMSBURG & CO.

Patentees and Manufacturers

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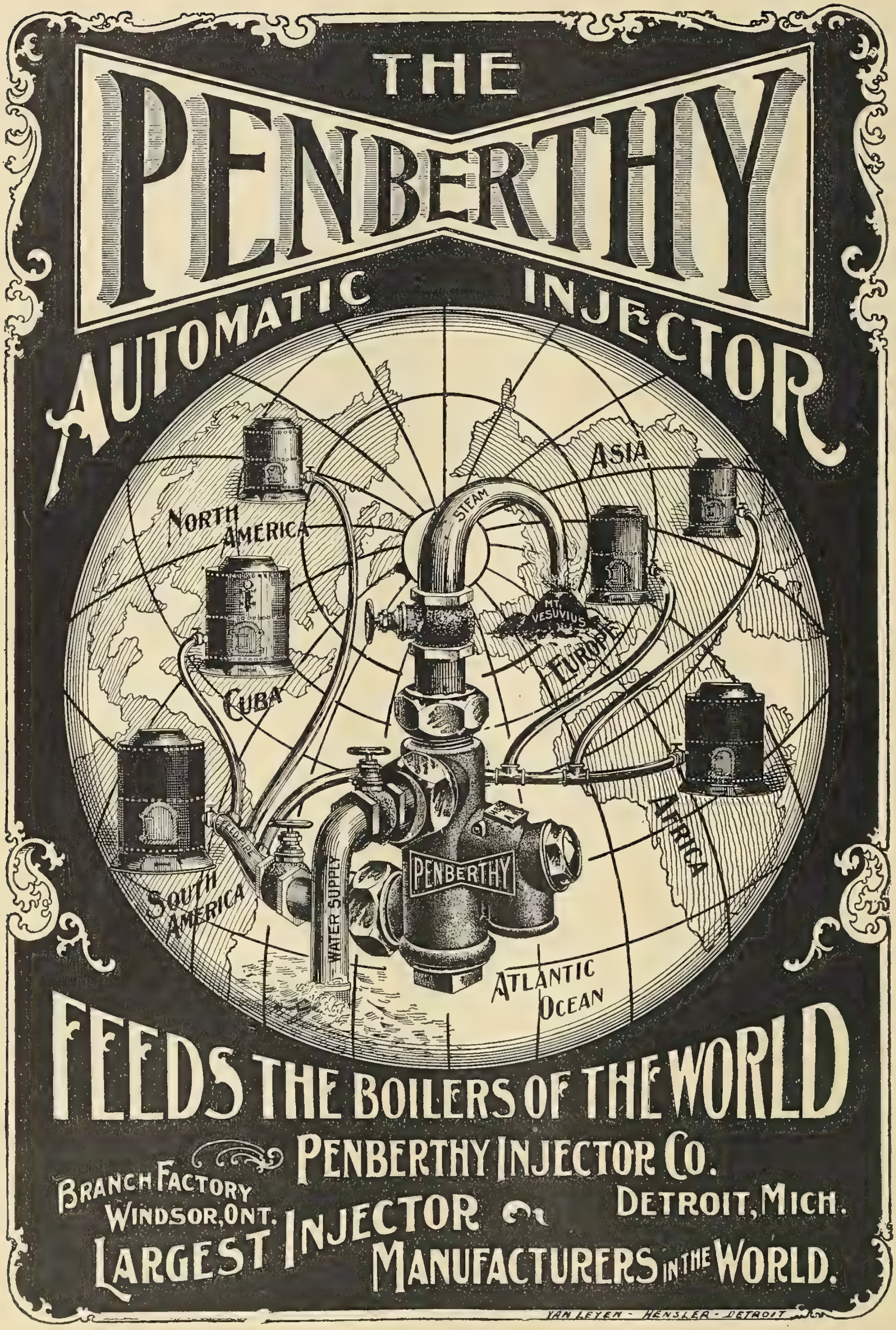
NEWPORT NEWS, VA.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FEEDS THE BOILERS OF THE WORLD
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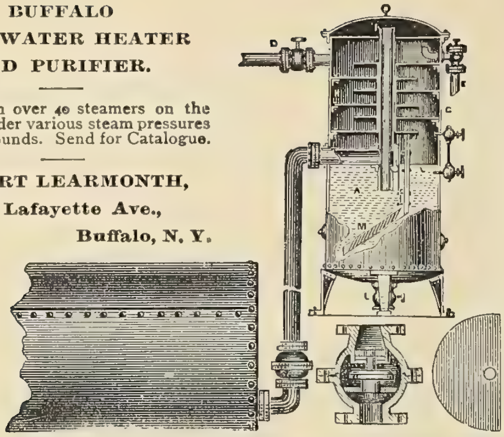
LARGEST INJECTOR MANUFACTURERS IN THE WORLD.
VAN LEYEN - HENSLER - DETROIT

BUFFALO FEED WATER HEATER AND PURIFIER.

In use on over 40 steamers on the lakes. Under various steam pressures up to 250 pounds. Send for Catalogue.

ROBERT LEARMONTH,
200 Lafayette Ave.,
Buffalo, N. Y.



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4-TONE SINGLE BELL CHIME WHISTLE.
THE ONLY CHIME WHISTLE WITH ADJUSTABLE BELL.
PRODUCES 4 TONES PITCHED TO A MUSICAL SCALE.
CAN BE HEARD AT A GREATER DISTANCE THAN A SINGLE-TONE WHISTLE.
EXTRA HEAVY FOR HIGH PRESSURE MARINE BOILERS.
SPECIAL AIR CHIME WHISTLES FOR NAPHTHA LAUNCHES.

KINSLEY MFG. CO.,

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ALCO POLISH

Expressly for Steamships, Yachts, Launches, Etc. Polishes all Metal Work and Silver. Is quick, brilliant and lasting. Contains nothing injurious. Manufactured by MARINE VAPOR ENGINE CO., Jersey City, N. J., U. S. A.

WINTERTON METAL POLISH

W. W. CALLERY & CO., Sole Manufacturers
36th and Butler Sts., PITTSBURGH, PA., U. S. A.
Hot Metal, Cold Brass, Copper, Nickel, Silver, Iron and Steel Polish.

IMPERIAL METAL POLISH.

IMPERIAL
METAL
POLISH.
EASILY APPLIED.
RADIANT IN LUSTRE.
INSTANTANEOUS IN ACTION.
ALL METALS, HOT OR COLD.
LIQUID OR PASTE.

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"AYROLITE"

IMPROVED METAL POLISH

The best article ever produced for use on Steamships and by all Engineers.

WILL NOT MELT OR EVAPORATE.

Is not affected by any climate. Bright finish and lasting lustre. Send 10 cts. for sample package, equal to 1 pint of liquid polish.

THE AYROLITE CO.,

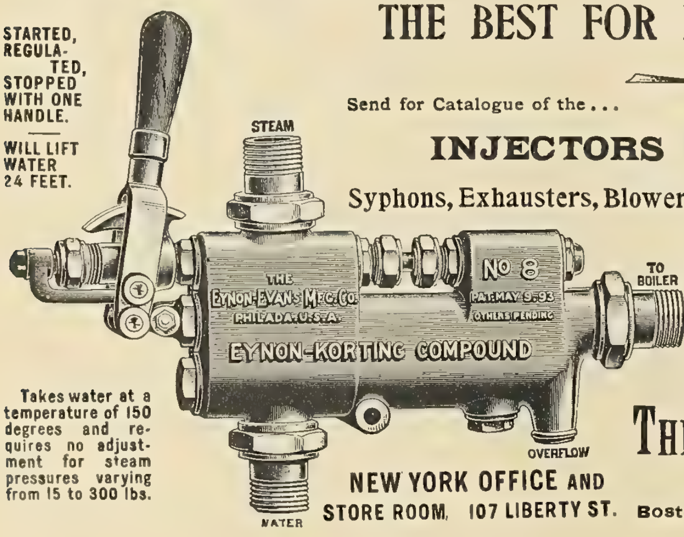
PITTSBURG, PA.

Eynon-Korting Compound Injector.

THE BEST FOR MARINE, LOCOMOTIVE AND STATIONARY BOILERS.

STARTED, REGULATED, STOPPED WITH ONE HANDLE.

WILL LIFT WATER 24 FEET.



Takes water at a temperature of 150 degrees and requires no adjustment for steam pressures varying from 15 to 300 lbs.

Send for Catalogue of the . . .

INJECTORS CONDENSERS

Syphons, Exhausters, Blowers, Ventilators, Blast Nozzles, Bilge-Pumps, Etc.

BRONZE FOUNDRY DEPARTMENT:

Copper Castings, Phosphor and Manganese Bronze, Red and Yellow Brass Castings.
Capacity 10,000 lbs. per heat.

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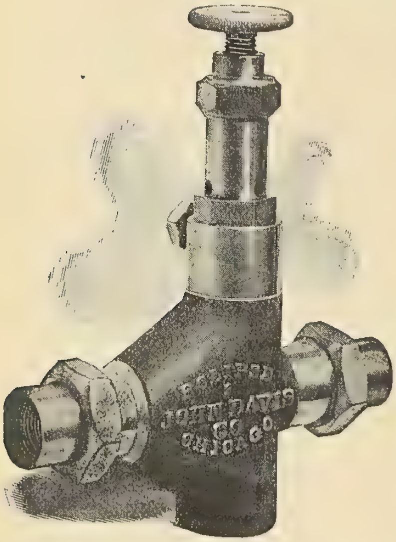
NEW YORK OFFICE AND STORE ROOM, 107 LIBERTY ST. Boston Office, 42 OLIVER ST.

THE
ECLIPSE MARINE REDUCING VALVE

Eclipses Them All.



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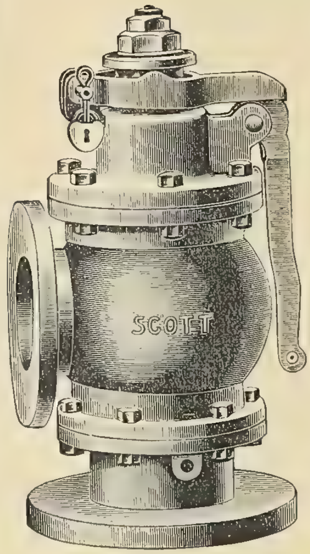
Intricate Parts.

Only three working parts, DISK, SPRING and PIN.

Send for Circulars and Prices.

THE JOHN DAVIS CO.,
51-79 Michigan St., Chicago, Ill.

SCOTT IMPROVED MARINE POP SAFETY VALVE.



Is made with a bevel seat to an angle of 45 degrees, and has a cam lever for raising valve off its seat when no pressure is on, or blowing off all steam when desired, as required by the U. S. Board of Supervisors and inspectors of steam vessels.

Marine Engineers Everywhere Endorse It.

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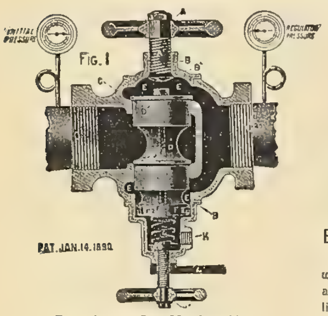
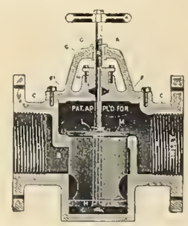
Received Medals and Diplomas at the World's Columbian Exposition.

Thousands in use all over the United States.



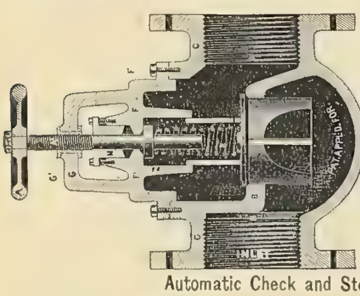
Regulator for Marine Use.

Connect inlet side to pipe from boiler. Open screw A full to the top, then set desired pressure with screw H.



Balanced Stop or Throttle Valve.

These valves can be opened and closed with a small hand-wheel at highest pressure, and if desired to use these valves for throttling engines, etc., a lever will be put on instead of hand-wheel, without extra charge. These valves will shut off perfectly tight.



For vertical pipes directly connected to boiler, these valves are made for extra heavy pressure; guaranteed to automatically close when boiler pressure falls one-half pound below pressure in header. The hand-wheel and screw-spindle are for shutting off positive when desired. The construction of this valve is arranged so as to stand the ordinary pulsations and remain noiseless, and by irregular working of boiler this valve adjusts itself to the proper opening and discharge of boiler, and thereby avoids the foaming, etc., of same.

Automatic Check and Stop Valve.

Every Machine sent on Trial. Send for Complete Catalogue.

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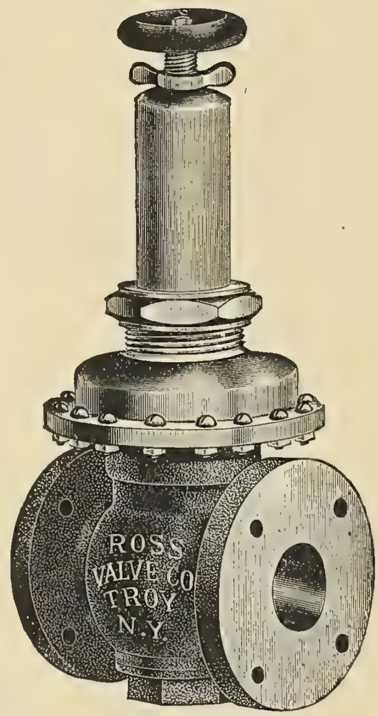

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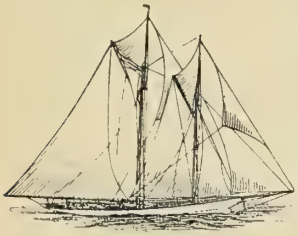

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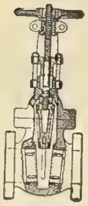

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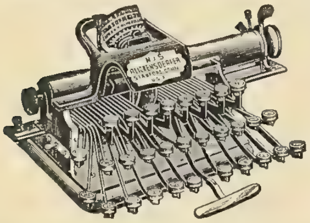

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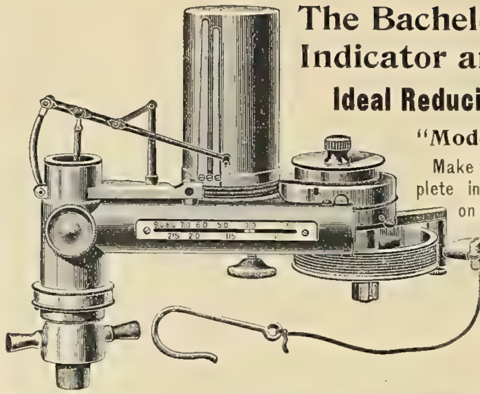

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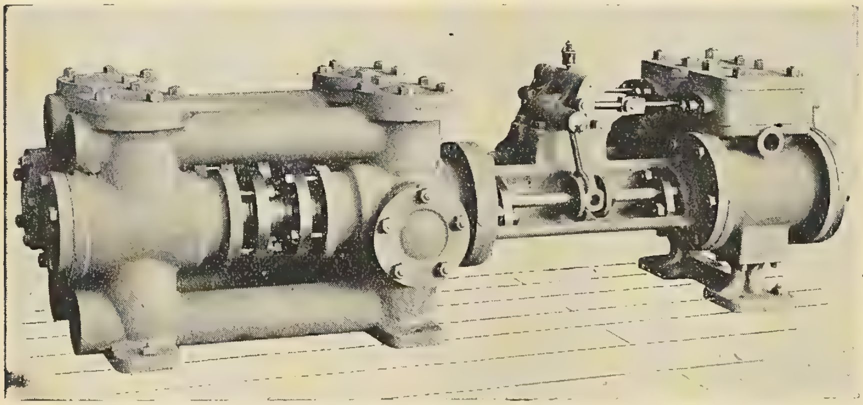

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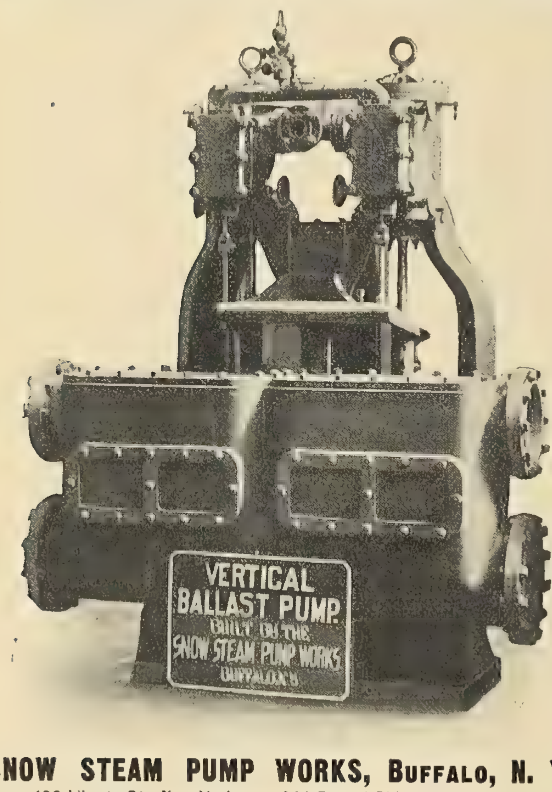

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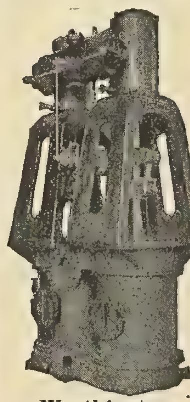

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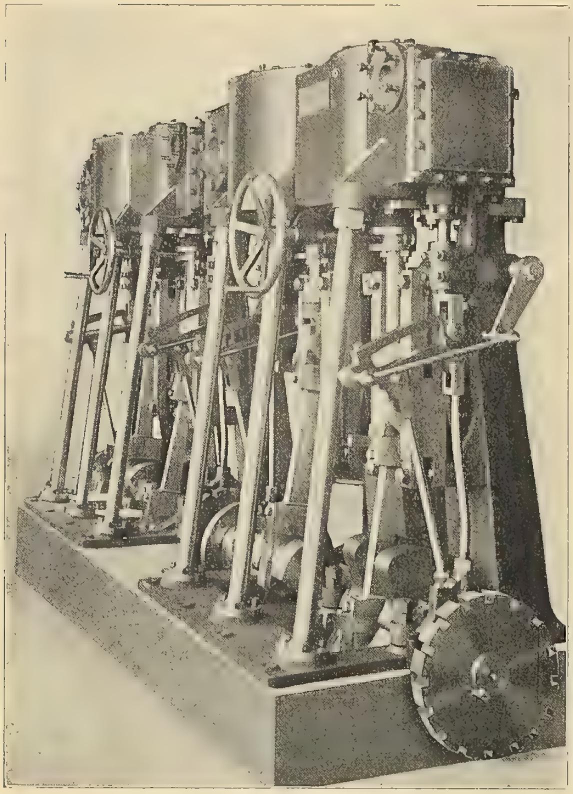

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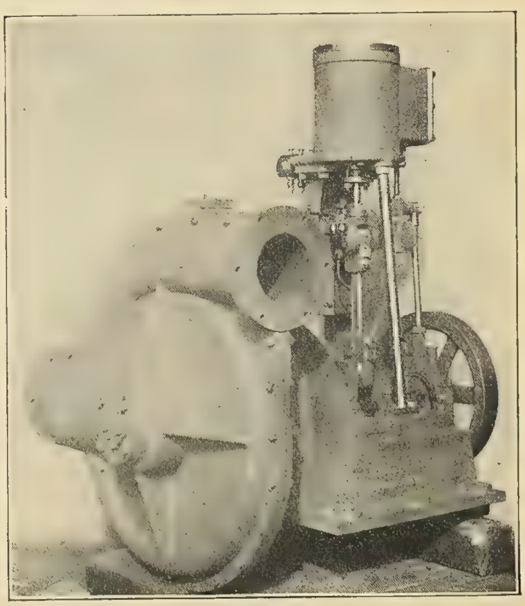

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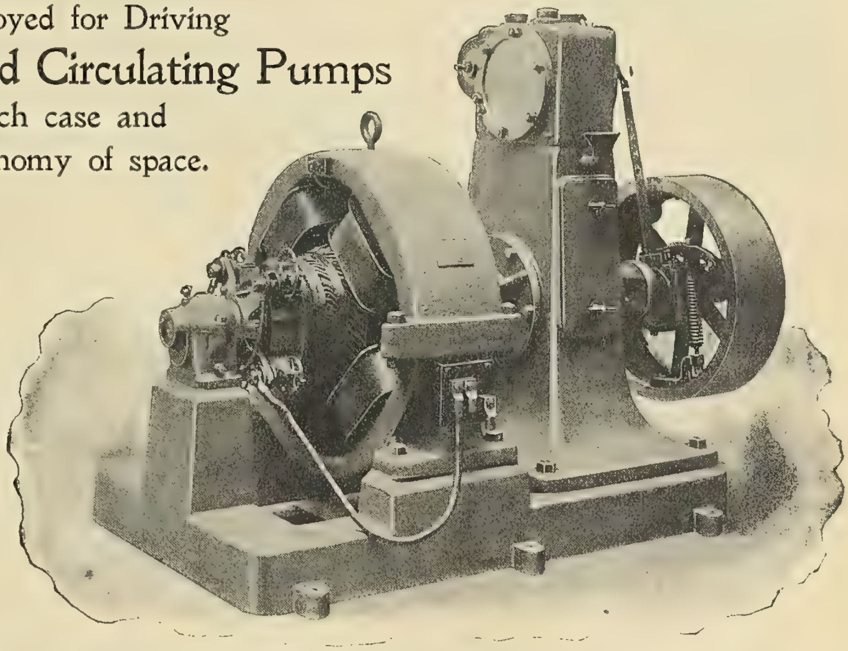

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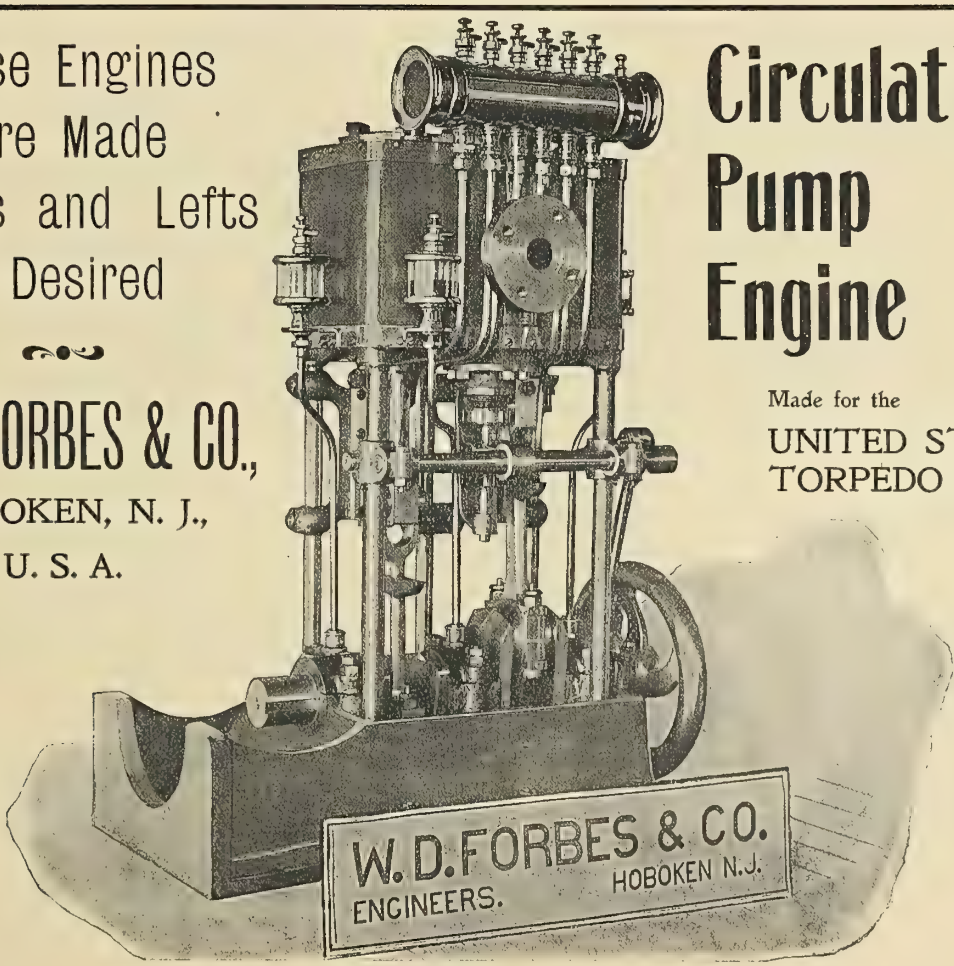

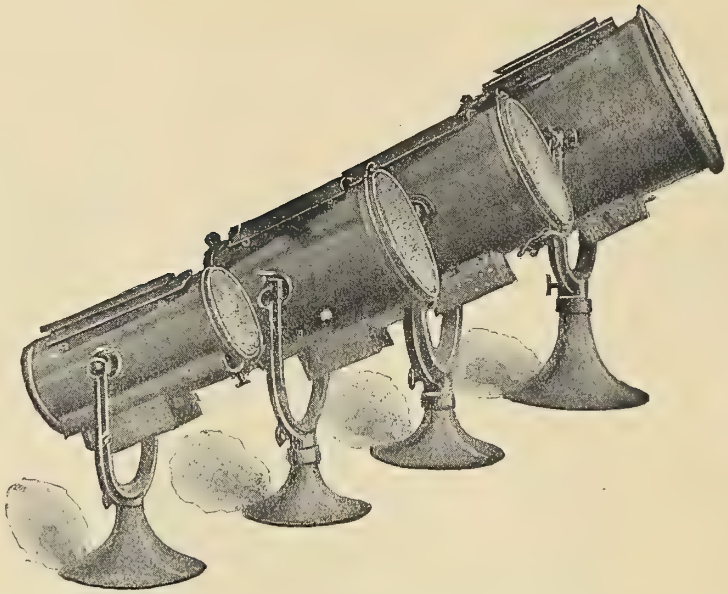

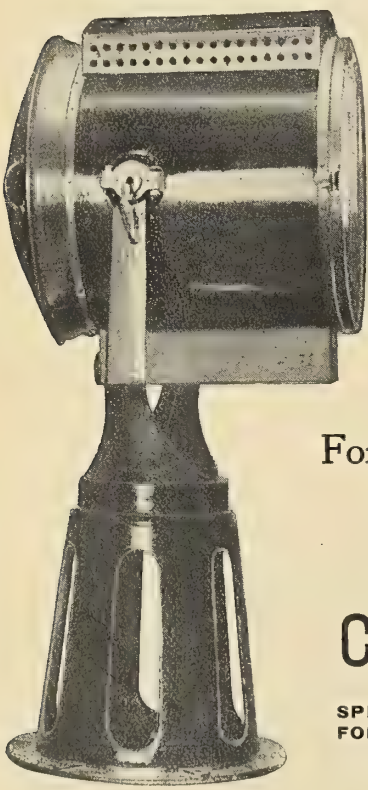

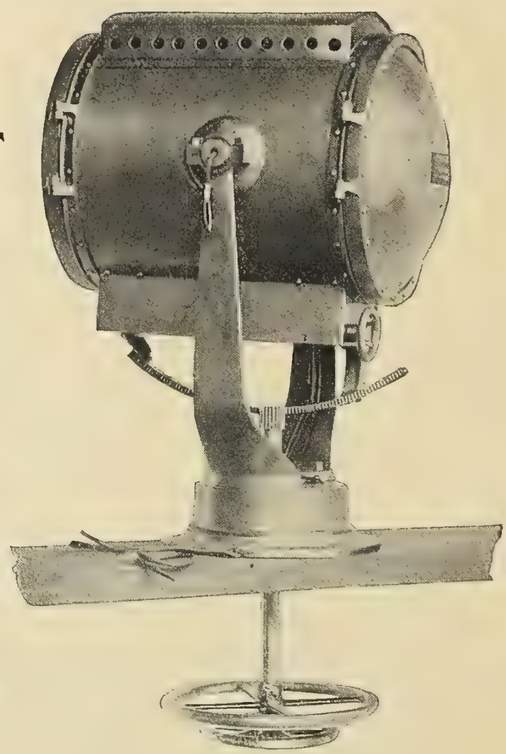

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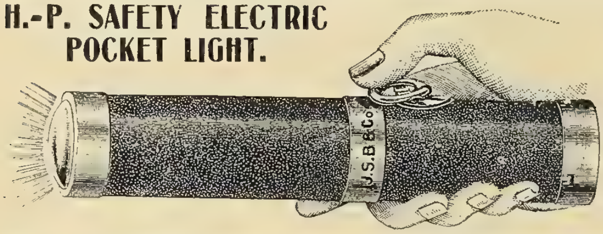

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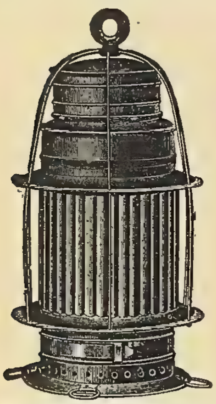

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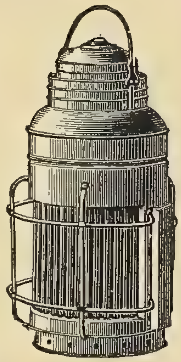

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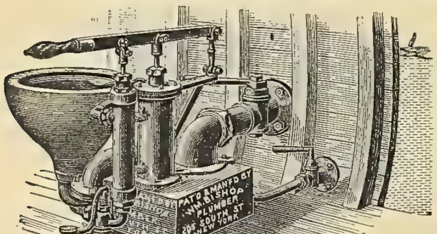

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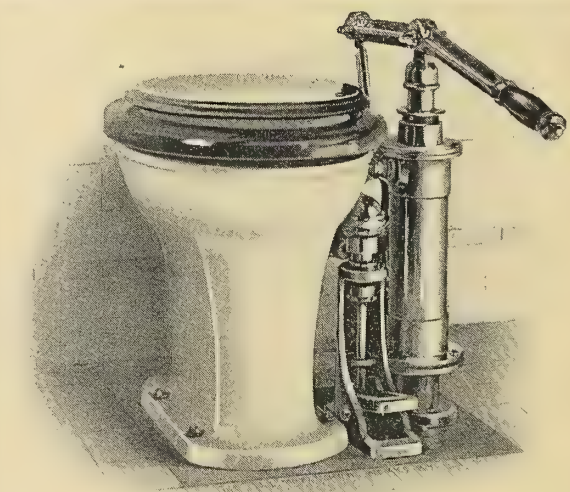

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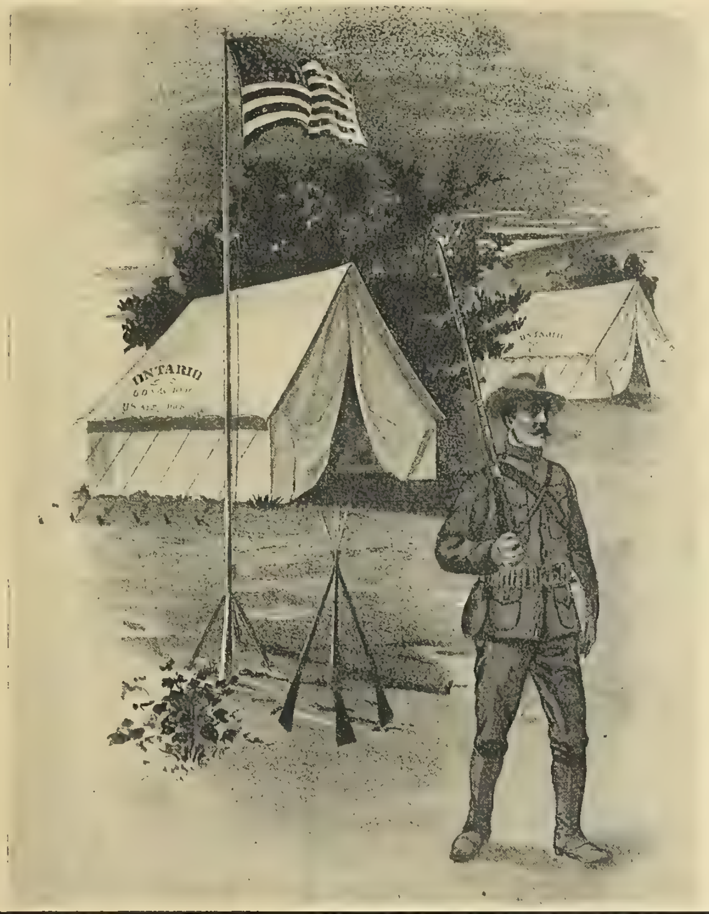
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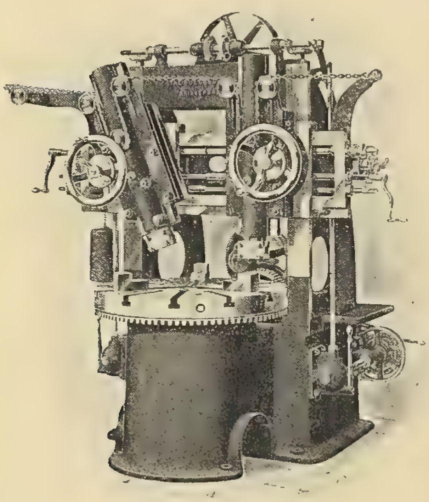

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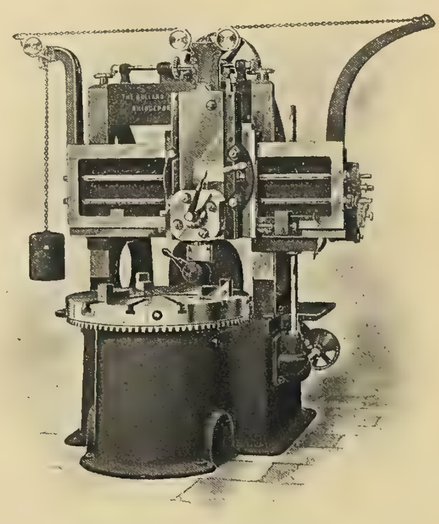

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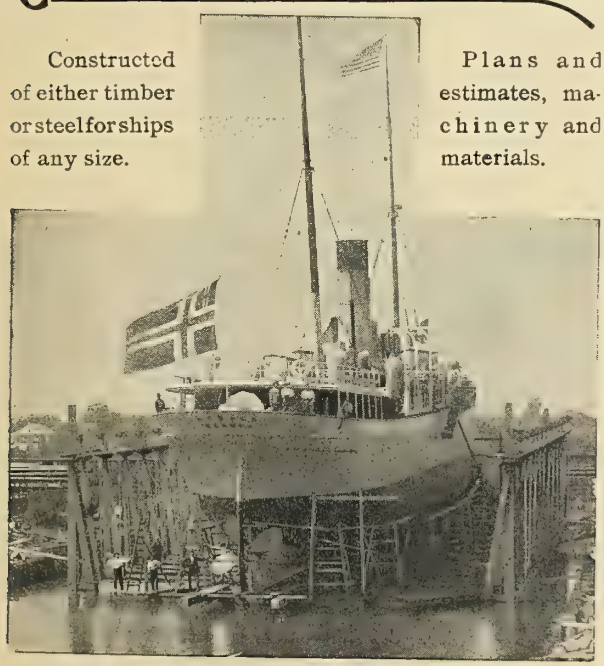

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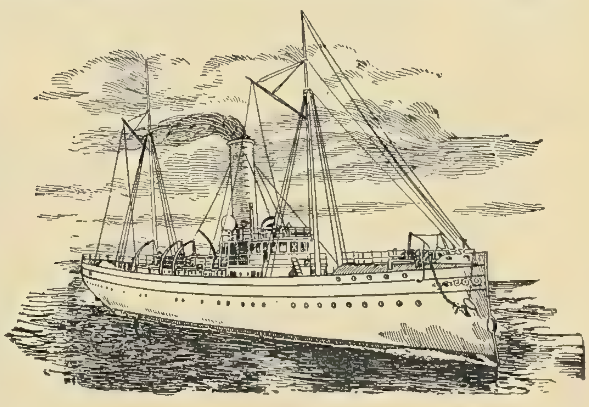

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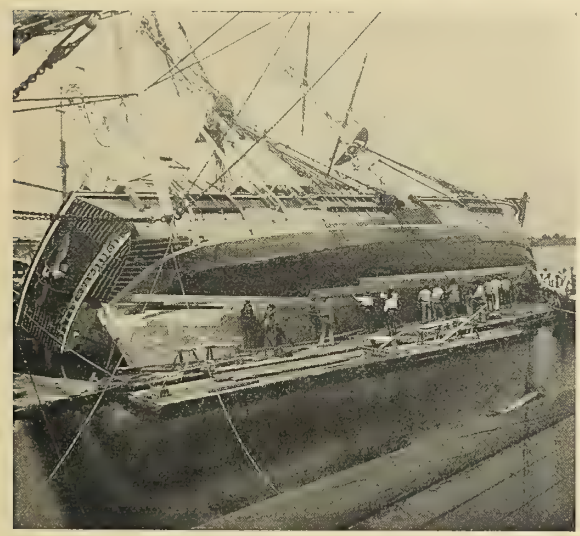

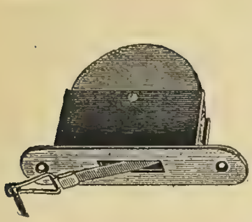

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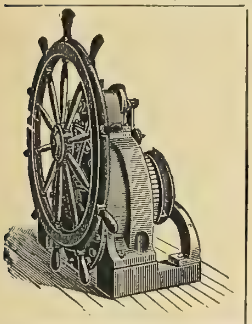

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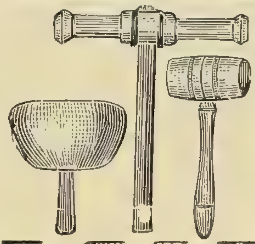

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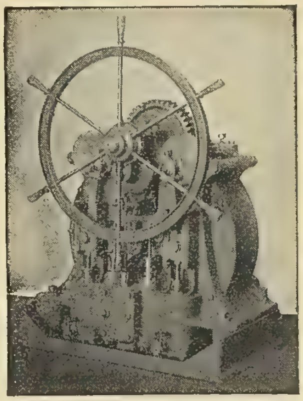

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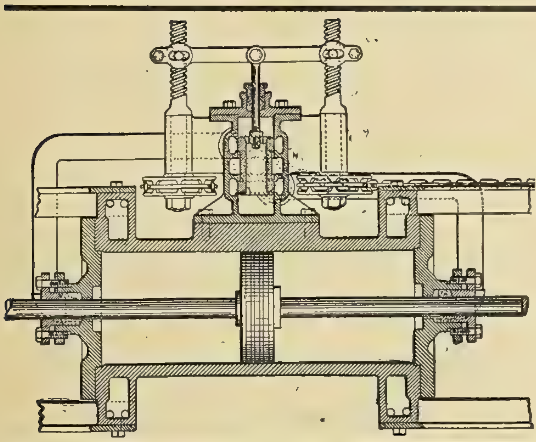

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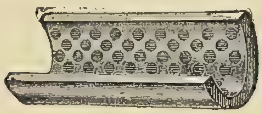

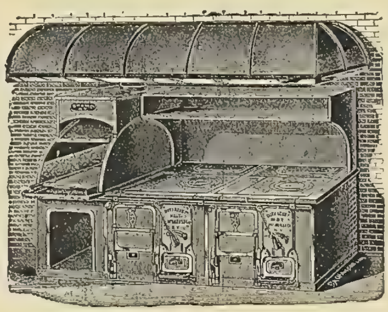

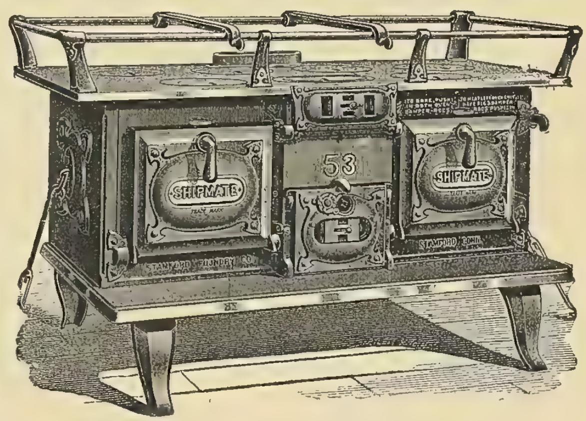

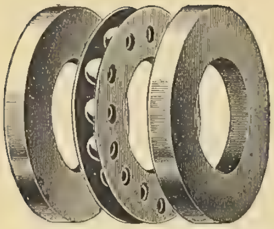

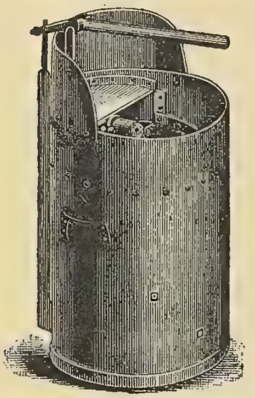

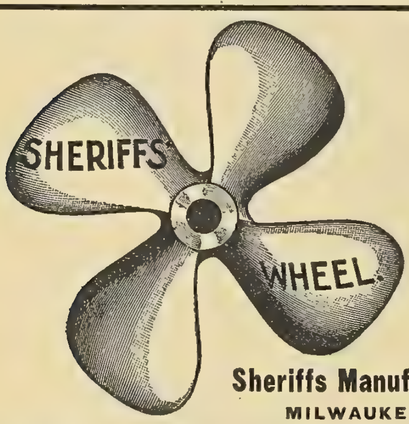

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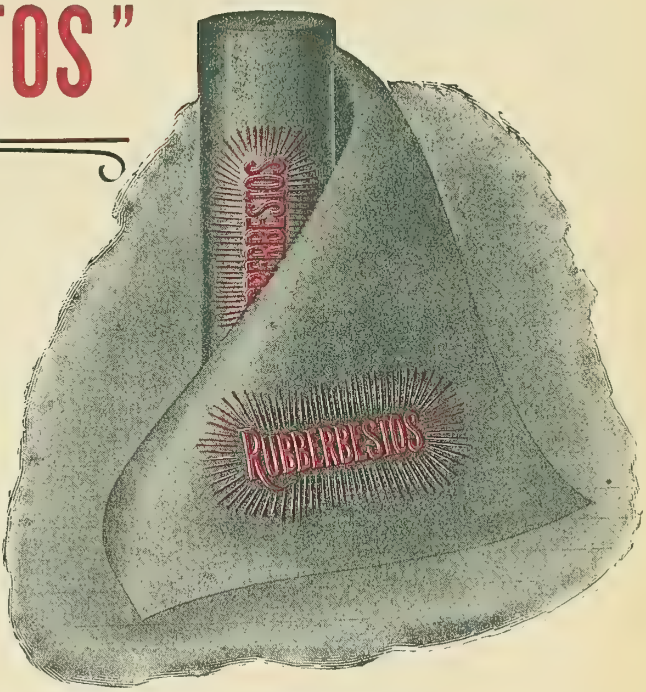

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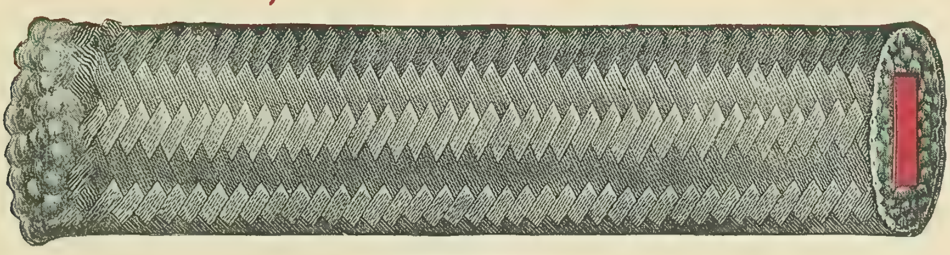

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Vol. 3. NEW YORK, MAY, 1899. No. 5

HOMEWARD BOUND—U. S. S. RALEIGH ON HER VOYAGE FROM MANILA TO NEW YORK.

HOMECOMING OF THE U. S. S. RALEIGH OF ADMIRAL DEWEY'S FLEET.

Among the U. S. vessels which participated in the sea fight at Manila, May, 1898, was the U. S. S. *Raleigh*. She also had the distinction of previously firing the first shot during the night entrance of the fleet into the bay. After the victory in Manila Bay the *Raleigh* rendered distinguished services in the subsequent operations under Admiral Dewey. Late last year she was ordered home, and she arrived in New York harbor April 16 to be greeted by the Mayor of the city officially and the citizens of New York in thousands unofficially.

The arrival of the war vessel on Sunday, in weather about as disagreeable as could be manufactured, diminished the size but not the earnestness of her welcome home after an absence of two years. It was not alone in honor of the *Raleigh*, however, that the tugs whistled, steamships saluted and the people cheered, but also because she was a representative of the fleet of Admiral Dewey, whose homecoming will undoubtedly be the occasion of one of the most patriotic demonstrations in the history of the country. At Quarantine the cruiser was met by the Spanish prize gunboats, *Sandoval* and *Alvarado*, and escorted by a fleet of screeching tugs she went up the North river as far as Grant's tomb and fired a national salute. Afterward the *Raleigh* anchored in the North river and visitors from shore were entertained while she remained in New York.

After her run of 12,584 miles the *Raleigh* looked as trim and serviceable as she did on the eventful first of May. Her log shows that she left Manila Dec. 15, 1898, and, in succession, touched at Singapore Dec. 21 to 31, Colombo Jan. 7, 1899, to Jan 13, Bombay Jan. 18 to Jan 19, Aden Jan. 27 to Feb. 1, Port Said Feb. 8 to Feb. 12, Alexandria Feb. 13 to Feb. 22, Malta Feb. 26 to March 6, Algiers March 16 (left), Gibraltar March 18, Punta Delgado March 23 to March 27, Horta April 1 (left), Bermuda April 9 to April 13, arriving at New York April 16.

Our artist has depicted the *Raleigh* "homeward bound" crossing the Atlantic on her westward voyage. This fine ship was built at the Norfolk Navy Yard, where she was launched in March, 1892, going into commission in April, 1894. Her dimensions are: Length, 300 ft.; beam, 42 ft.; depth, 18 ft., and displacement, 3,213 tons. She is a twin screw vessel, fitted with triple expansion engines of nearly 10,000 I. H. P., and on her trial she attained a speed of 19 1-2 knots. She is armed with ten 5 in. rapid-fire and one 6 in. slow-fire guns; also eight 6-pounders and four 1-pounder rapid firers, and machine and field guns. She is also provided with two Whitehead torpedo tubes. She is classed as an unarmored steel protected cruiser, having a protective deck ranging in thickness from 2 1-2 in. down to 1 in.

A significant incident of the voyage occurred while the *Raleigh* was steaming out of Gibraltar. She met Admiral Camara's fleet coming in, and Captain Coghlan politely raised the Spanish ensign and fired a salute, which was quickly responded to by the Spanish flagship.

THE ARTHUR SEWALL, AN AMERICAN SHIP-ENTINE BUILT OF AMERICAN STEEL.

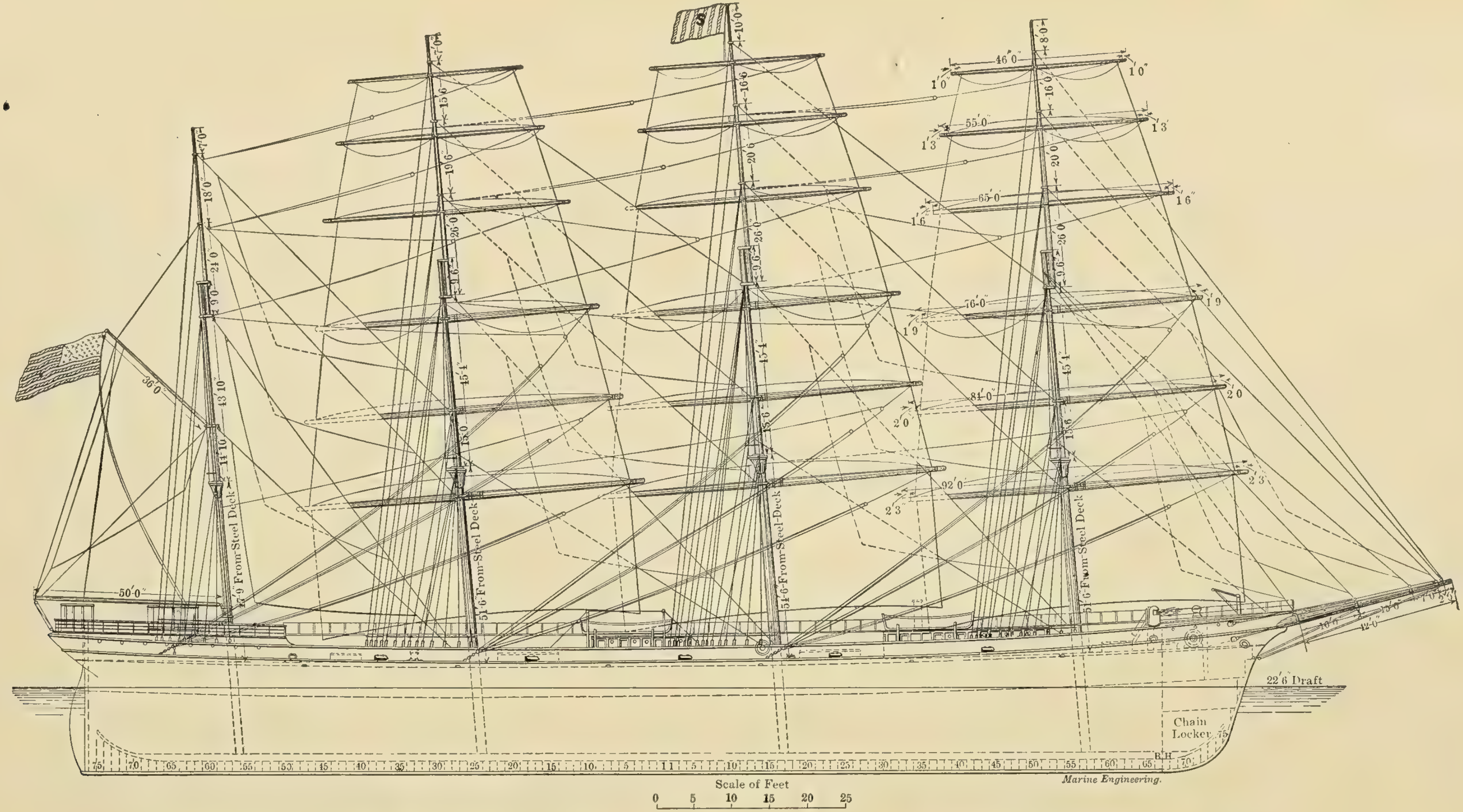
This fine vessel is the largest steel sailing ship ever built in the United States, and is the third steel vessel built by Arthur Sewall & Co., shipbuilders and ship owners of Bath, Me. She was launched Thursday, February 23, and is at the present time engaged in loading for a voyage. The *Arthur Sewall* is a strong, rigid steel vessel, and her scantlings are equal to or in excess of the requirements of all the first-class classification societies. It was originally intended that she should receive the highest rating in the British Lloyds, but the owners finally decided to class her in both the Bureau Veritas and the American Bureau of Shipping.

The principal dimensions of this new vessel are:

Length over all	about 354 ft.
" L. W. L.	332 "
Beam moulded	45 "
Depth, side	27 " 3 in.
" center	28 " 3 "
" of hold	25 " 8 "
Designed load draught	22 " 6 "
Registered length	332 "
" beam	45 "
" depth	25.6 ft.
" gross tonnage	3,209.3 tons.
" net "	2,919 "

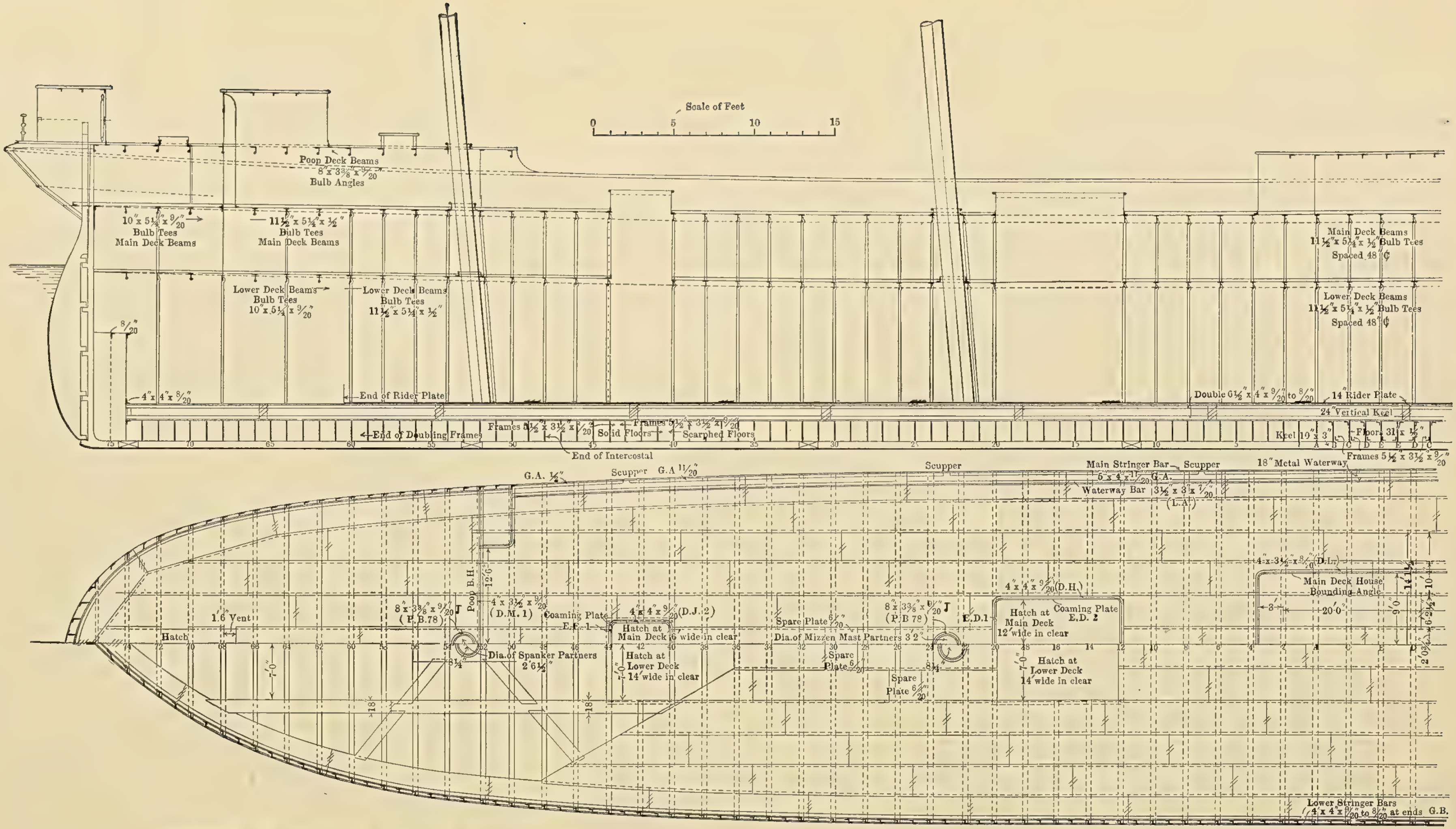
The *Arthur Sewall* has a dead rise of 20 in. and an easy turning bilge. She has the usual tumble home amidship; and a deck camber of 12 in. in 45 ft. The frames are 5 1-2 in. by 3 1-2 in. by 9-20 in. angle bars spaced 24 in. apart, with a reverse frame 4 in. by 3 in. by 9-20 in. angle bar on every frame running alternately to the main deck and lower deck stringers. The floor plates are 2 ft. 7 in. deep in the center and 10-20 in. thick; they are furnaced and carried in one piece from a point near the center line, to the upper turn of the bilge. The vessel has a bar keel, and her keel, stem and stern post are the same size, viz., 10 in. by 3 in. The vertical keel is placed on top of the floors and consists of a plate 24 in. by 15-20 in. placed vertically with two angle bars on the top and two on the bottom, each 6 1-2 in. by 4 in. by 9-20 in.; a rider plate is fitted on the top 14 in. wide and 14-20 in. thick. There are two side keelsons on each side of the vertical keel, and on the side of the vessel midway between the floors and the lower deck beams, an orlop stringer plate is worked 45 in. wide by 9-20 in. thick. This plate is stiffened on the inside by longitudinal angle bars and is well bracketed to every alternate frame.

The *Arthur Sewall* is a two decked vessel, and both the lower and main decks are continuous and extend throughout the vessel's length. The main deck beams are of bulb T sections, 11 1-2 in. deep and 10-20 in. thick, spaced 48 in. apart. This deck is plated throughout and sheathed with yellow pine 5 in. by 3 1-2 in. The lower deck is 8 ft. 3 in. below the main deck and runs parallel to it. The beams of this deck are the same size and have the same spacing as the main deck beams. It is plated with steel for about 200 ft. amidship and a wood deck of yellow pine 6 in. by 3 in. is laid throughout. The bulwarks of this vessel are 5 ft. high amidship, but this dimension is increased fore



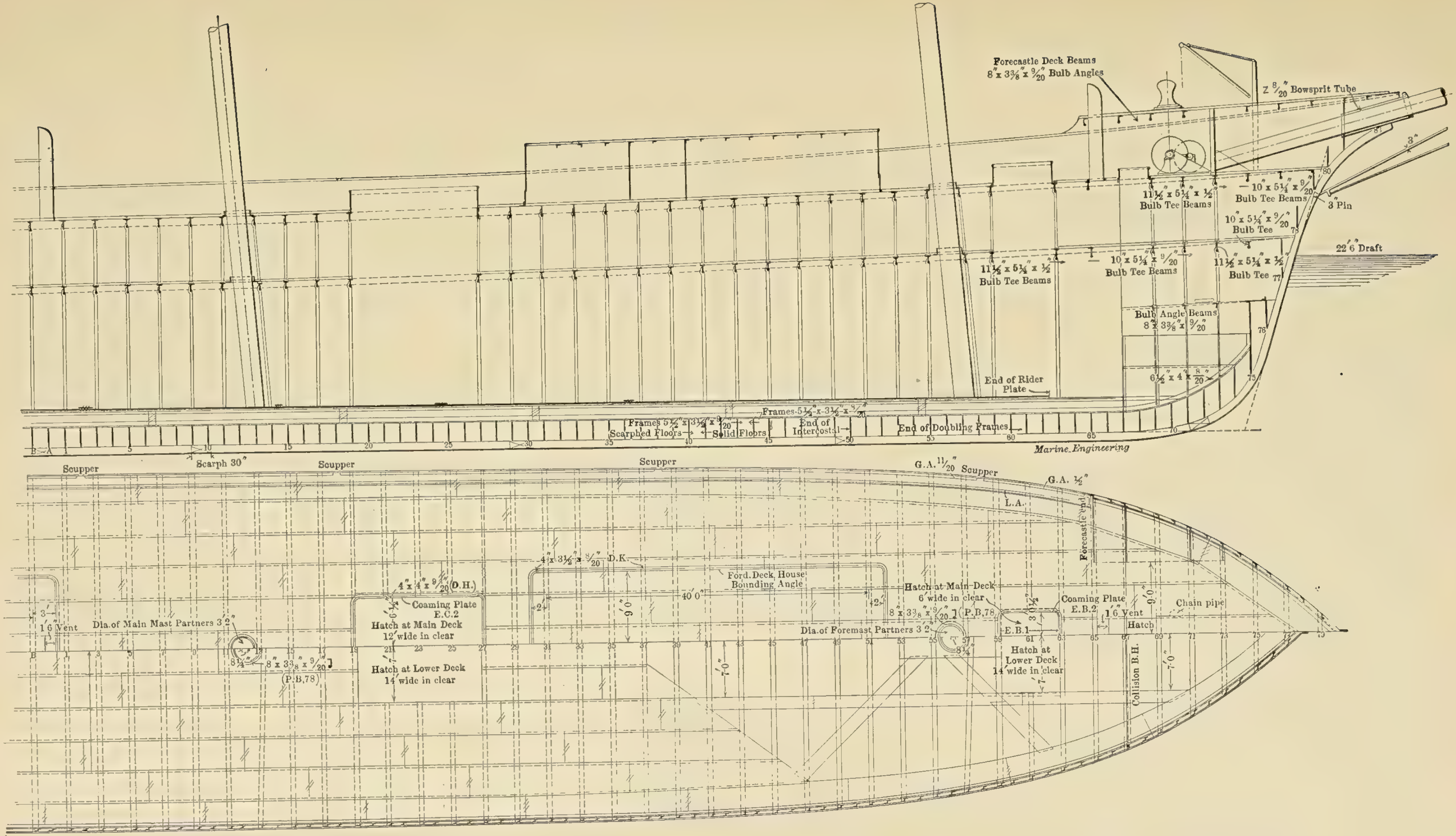
SAIL PLAN OF THE NEW AMERICAN STEEL SHIPENTINE ARTHUR SEWALL, 2,860 TONS. BUILT BY ARTHUR SEWALL & CO., BATH, ME.

and aft and the apparent sheer of the bulwarks is not parallel to the line of the main deck. By this arrangement a forecastle forward and poop aft with full head-room are obtained without any conspicuously high houses on the ends. The forecastle and poop decks are worked parallel to the line of the main deck and a turtle back varying in depth connects these decks to the steel bulwarks. The building tonnage of the *Arthur Sewall* is 2,860 tons and the Lloyds numerals for the vessel are: 1-2 girth 46 ft., depth 28.25 ft., 1-2 beam 22.5 ft., length 328.3 ft. First numeral or transverse number = 96.75, second numeral or longitudinal number = 31,763, ratio length to depth 11.62, ratio length to beam 7,295. The vessel has two roomy steel deck houses. The forward house, which is 46 ft. long and 18 ft. wide, contains the crew's quarters. This room contains 20 berths, and it is well lighted and venti-



WORKING DRAWINGS OF THE NEW STEEL SHIPENTINE ARTHUR SEWALL. BUILT BY ARTHUR SEWALL & CO., BATH, ME.—AFTER END.

lated with both air ports and skylights. The remainder of the forward house is devoted to the galley, donkey boiler, engine room and coal bunker. The amidship deck house is 26 ft. long and 18 ft. wide. It contains the carpenter's shop, and six rooms for the petty officers. Aft in the poop is a well arranged, commodious cabin, finished in white and artistically decorated for Captain James F. Murphy, who will be the ship's commander, and the Commodore of the Sewall fleet of sailing ships. This cabin, which is 48 ft. long and 38 ft. wide, is well lighted and ventilated by means of skylights. In the forward part is the dining room and adjoining is the main saloon. A hallway is situated on the port side, opening from which are the officers'



WORKING DRAWINGS OF THE NEW STEEL SHIPENTINE ARTHUR SEWALL. BUILT BY ARTHUR SEWALL & CO., BATH, ME.—FORWARD END.

staterooms. Captain Murphy's apartments are on the starboard side. The cabin is supplied with a large steward's pantry, store rooms, lavatories and bath rooms. A spiral stairway leads from the cabin to the chart house on the poop deck. This house is 14 ft. by 16 ft., and part of it will be used for the accommodation of two passengers. The vessel is steered by screw steering gear, the helmsman being protected by a steel hood open at the forward end. A large fore and aft flying bridge is fitted, connecting the poop, deck house and top gallant forecastle. This bridge is portable in wake of the hatches and in bad weather it will undoubtedly prove a great convenience.

The *Arthur Sewall* will carry 5,000 tons deadweight on a draught of 22 ft. 6 in., and she will stand up without ballast when light in port. The vessel has great stability at light draught, and she will prove a good, seaworthy, stable ship when loaded with any homogeneous cargo. Her proportions of length to depth and length to beam are rather excessive, for she is approximately an *Erskine M. Phelps*, with a parallel middle body of 20 ft. inserted amidship. She is not by any means a full ship, her block co-efficient at the designed load draught excluding the keel being only about .73. The *Arthur Sewall*, like her predecessors, has a neat, well proportioned sail plan. The lower masts and topmasts are of steel in one length, and the top gallant and royal masts are of wood in one piece. The spike bowsprit and three lower yards on each mast are made of steel, while all the remaining smaller spars are of wood. The fore, main, mizzen and jigger lower masts, including the topmasts, are 107 ft., 110 ft., 107 ft., and 100 ft., respectively, above the main deck. The fore top gallant and royal masts are 70 ft. long, the main 72 ft., the mizzen 61 ft. and the jigger 49 ft. long. The lower yards are each 92 ft. long; the topsail yards measure 84 ft., the upper topsail yards 76 ft., the top gallant yards 65 ft., the royal 55 ft. and the skysail 46 ft. She has six yards on each of the fore, main and mizzen masts, and being rigged as a shipentine, she carries no yards on the jigger mast. The spike bowsprit projects 45 ft. beyond the bow; the spanker boom is 50 ft. long and the gaff about 36 ft. She has four head sails, three main, three mizzen and four jigger stay sails, which makes a total of thirty-four sails all told. The standing rigging is of wire rope set up with turnbuckles. The fore, main and mizzen masts have each five shrouds and two backstays, two topmast backstays, two topgallant, and two royal backstays. The jigger mast is fitted with four shrouds and one backstay, two topmast backstays, one top gallant and one royal backstay.

The *Arthur Sewall* is fitted with all modern appliances for the rapid handling and stowing of cargo. A donkey engine of 25 H.P. works the ship's windlass by means of a messenger chain, and the same motive power is used in port for discharging and taking on cargo. The vessel is equipped with three bower anchors, two of which weigh 5,000 lb. each, while the third weighs 4,250 lb., excluding stock. She has also one 1,700-lb. stream anchor, and two kedges of 850 lb. and 560 lb. weight respectively. Her main cable consists of 300 fathoms of 2 5-16 in. stud link chain, and she is also fitted with 120 fathoms of 1 3-16 in. stream chain and 90 fathoms of flexible steel wire tow line, besides the usual hawsers and warps. The windlass is of the steam capstan "Hyde" type, and two hand capstans have also been fitted. The running lights are carried in steel light-houses forward. There are two large portable cranes on the forecastle deck for the handling of the anchors. The total complement of the *Arthur Sewall* will consist of the Captain, four Mates, Engineer, Sail Maker, Cook, Steward, twenty seamen and eight boys, or thirty-seven men all told.

The cost of the *Arthur Sewall* cannot at this time be accurately ascertained, but it will probably be about $155,000, or a little over $48 per ton. It is indeed gratifying to know that Arthur Sewall & Co., without reducing the wages of their shipyard mechanics, have been able to construct two steel sailing ships, the *Erskine M. Phelps* and the *Arthur Sewall*, at their own yard, at a price about equal to that paid by British builders for the same class of tonnage. They have had to pay more than British builders for labor, but they have saved by duplication and the lower cost of American steel. This latter fact is particularly significant and worthy of note, for when the *Dirigo* was constructed, only five years ago, the builders bought all their steel from Motherwell, near Glasgow, Scotland, and at that time the British steel, plus the price of transportation, could be obtained cheaper than steel of domestic manufacture. Arthur Sewall & Co. are now about to lay the keel of another shipentine, which will be very similar to the *Arthur Sewall*. The accompanying plans show the design and dimensions of this fine vessel very clearly.

The *Arthur Sewall* is in reality a duplicate of the *Erskine M. Phelps*, with an additional parallel middle body of 20 ft., inserted amidships, and the scantling and stiffening increased on account of the additional length. William A. Fairburn, of Bath, Me., drew the plans for these vessels and acted as consulting naval architect for the builders and owners, Arthur Sewall & Co.

THE STEAM YACHT AS A NAVAL AUXILIARY IN THE LIGHT OF SPANISH WAR EXPERIENCES.*

BY W. P. STEPHENS.

The subject of this paper is but one of many that have already come before the Society in their theoretic aspects, and now, when tried by practice, it presents results which seem to be both definite and conclusive; and from which some useful lessons may be drawn.

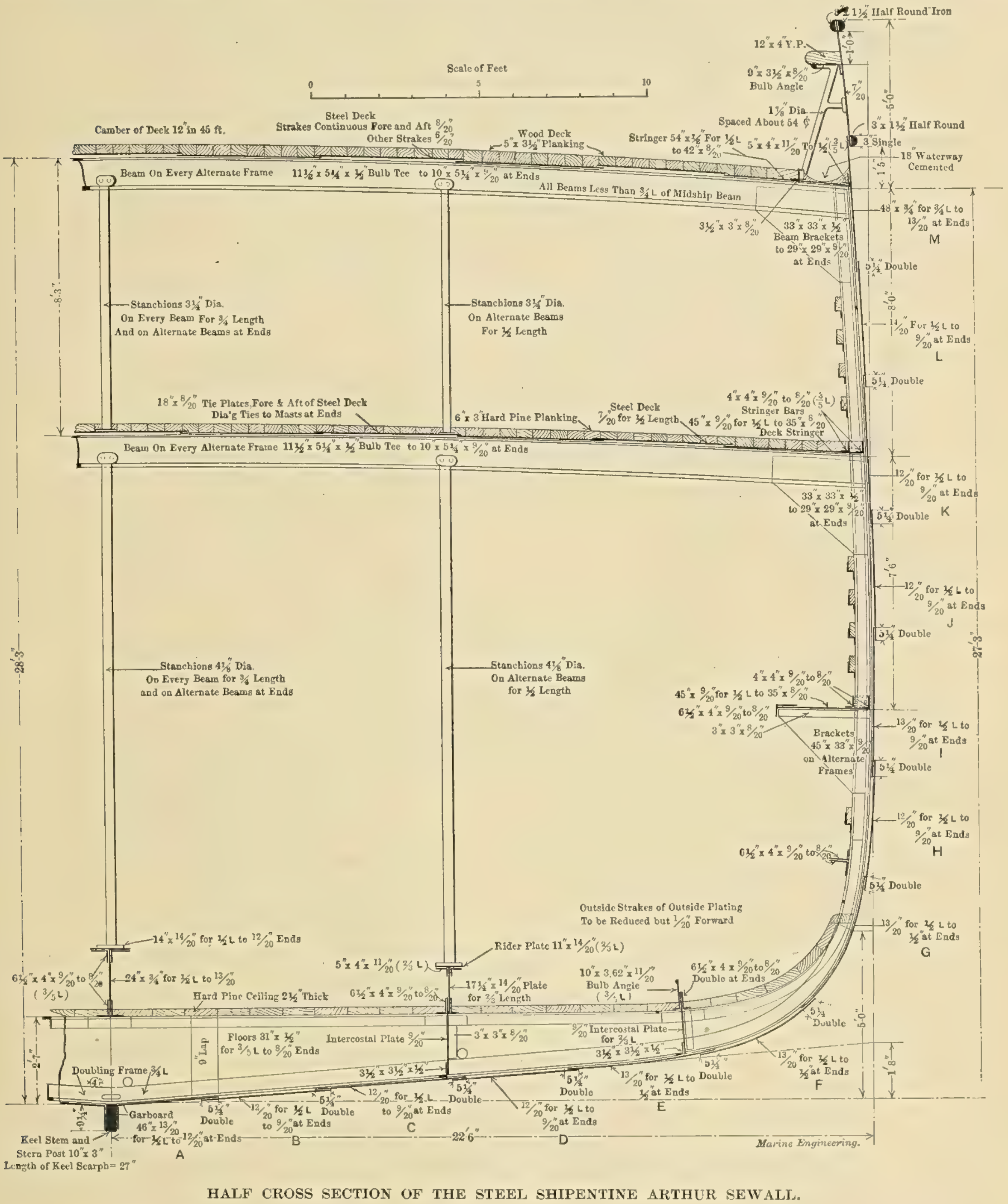
The work of reconstruction which has been under way in the United States Navy for the past fifteen years has been limited almost entirely to the strictly fighting arm of the service—the battleships, cruisers and torpedo craft. Indispensable as they are, these of themselves do not constitute a perfect navy; in fact they are of comparatively little use without a large attendant fleet of auxiliary craft; transports, colliers, water boats, repair ships, supply ships, hospital ships, and small craft for various uses.

The condition of the Navy at the outbreak of hostilities between the United States and Spain may be briefly summed up as strong in its personnel; comparatively strong in fighting vessels, guns, and armor; and absolutely unprovided with auxiliaries of all kinds. Of all the urgent work demanded both ashore and afloat, nothing was more immediate and pressing than the creation of an efficient fleet of auxiliaries.

Among the numerous classes coming under this general head is one that is hardly accorded the distinction of a specific title in naval programmes, but which, in the present case, was needed for three im-

* Read at the Sixth General Meeting of the Society of Naval Architects and Marine Engineers, in New York.

portant uses, as follows: First. For sea service as tenders to the blockading fleet, and general service in the shoal harbors and rivers of the West Indies, where the war vessels were barred by their draught. Second. For picket duty off shore, constituting the "Second Line of Defense." Third. For harbor patrol when the possibility of war had almost crystallized into a certainty. This Board proceeded at once to examine a very large number of vessels, ranging from the large passenger steamers of the American Line down to the smaller sizes of tugboats and yachts; and, in accordance with its reports, vessels



HALF CROSS SECTION OF THE STEEL SHIPENTINE ARTHUR SEWALL.

duty in connection with the guarding of mine fields and the enforcing of the war regulations governing ports and harbors.

The preparation of this particular branch was but one detail of the important task entrusted to the "Naval Auxiliary Board," specially created at a time were purchased from the special appropriation made by Congress for the purpose of defense.

For the work above outlined two classes of vessels were selected, the ocean-going tug and the steam yacht, the latter to the number of twenty-seven. The selection was made from many localities, several of the yachts coming from the Great Lakes. The vessels were mainly purchased direct from the owners, the price being fixed by the Board. As soon as the transfer of title was completed the yacht was delivered at the nearest navy yard, where the work was pushed as rapidly as possible. As a matter of course, the majority of the yachts hailed from New York, and the work on them was consequently executed at the Brooklyn Navy Yard.

The capabilities of this material for an emergency fleet for successful conversion to war purposes were, as we shall see later, not of the best; but the facilities for carrying out the work were in the main satisfactory, the skilled labor and the necessary material being readily obtained. The only difficulty encountered in this part of the work was in the detail of armament, there being a lack of some of the sizes of guns best fitted for these small vessels.

To the yachtsman at least, the sight of the well-known vessels as they left the Navy Yard was a surprise and also a shock; under a dull monochrome of "war paint" (lead color) covering everything from water line to truck, the distinctive color scheme of the yacht was effaced entirely; there was no longer a trace of the green "boot top," the jet black topsides relieved by gilded cove and trail boards and figurehead, with the sheer cut out cleanly by a strip of polished teak. The rich brown of the deck houses, the bright yellow of the spars, and the white sails set off by the parti-colored burgee at each truck, had all disappeared. The bowsprit was sawed off just outside the gammon iron and brought to a blunt point, the fore topmast shared a similar fate, projecting but a few feet above the cap, and the mainmast had disappeared entirely. A pair of 3 or 6 pounders grinned menacingly from the forecastle, a couple more from the quarterdeck, and bridge and deck house each showed an automatic gun. The rowing boats were retained, but the steam and naphtha launches were left ashore.

As each vessel was completed she was despatched to her station, many going direct to Key West, and from there to the Cuban coast; others were stationed along the coast of the eastern and Atlantic states to give warning of the approach of the expected Spanish fleet, while the smaller ones were assigned to duty in the harbors of New York, Boston, and other important seaports. At the outset the Sea Picket division was regarded as the most important of the three, but as matters turned out it had nothing to do, and after Cervera's fleet took refuge in Santiago Harbor, it was withdrawn and the vessels despatched to more southern stations. The work of the Harbor Patrol fleet was also very light, mere policing of the mine fields against the intrusion of garbage scows and coasting schooners.

While specific information as to the individual performances of the main division of the yacht fleet in actual service is not yet at hand, enough is known to establish the fact that the fleet, as a whole, acquitted itself creditably and fully justified its creation. While some of the converted yachts proved failures and entirely unfit for sea work, and others were only partly satisfactory, many of them have done excellent work under trying conditions. The part played by the Gloucester and the Vixen at Santiago was such as to bring them into special prominence, but the Mayflower, Yankton, Scorpion, and others have done regular and consistent service, though under conditions which have attracted less attention to them.

The work of laying up this fleet really began before the actual cessation of hostilities, the smaller yachts of the Harbor Patrol being withdrawn and placed out of commission at the Brooklyn Navy Yard and other points. One yacht, the Free Lance, presented to the Government by her owner, F. Augustus Schermerhorn, without conditions, was returned to him as soon as the need for her services in the New York Harbor Patrol fleet was over. Another similar gift, the Buccaneer, presented by W. R. Hearst, was also returned later on, being in Cuban waters when hostilities ceased. At the time of writing, most of the yachts have returned from the West Indies, the majority of these to go out of commission. The Gloucester, Scorpion, Vixen, Mayflower, and others of the larger and abler, are still in service. One yacht, a new craft uncompleted at the time of purchase and placed in commission only after the need for her was past, has been reserved for the special use of the President, a service heretofore performed by such Government tugs, lighthouse tenders, or other small craft as were temporarily available. She has been named the Sylph, and her original arrangements, as a private yacht, have been modified to suit this new use. No decision has yet been made as to the disposal of the yachts remaining, twenty-five in all, but it is probable that most of them will be offered for sale, ultimately returning to the pleasure fleet.

In summing up what has been at best an experiment arising from an emergency which should never have occurred, it may be said in regard to the home divisions of the converted fleet, the sea pickets and harbor patrol, that the course of the war has been such that no serious or prolonged service was required of either, and the merits of the fleet were not put to a practical test. Had, however, the anticipated attack upon the North Atlantic coast proved a reality, it is safe to say that the yachts would have met all expectations. In the case of the third division of the fleet, the vessels were put to the severe test of prolonged service at sea, under conditions for which they were never intended, and they were also engaged in attacks upon land fortifications and in some cases in engagements on the sea. The result of this test has been, on the whole, quite as satisfactory as could have been expected.

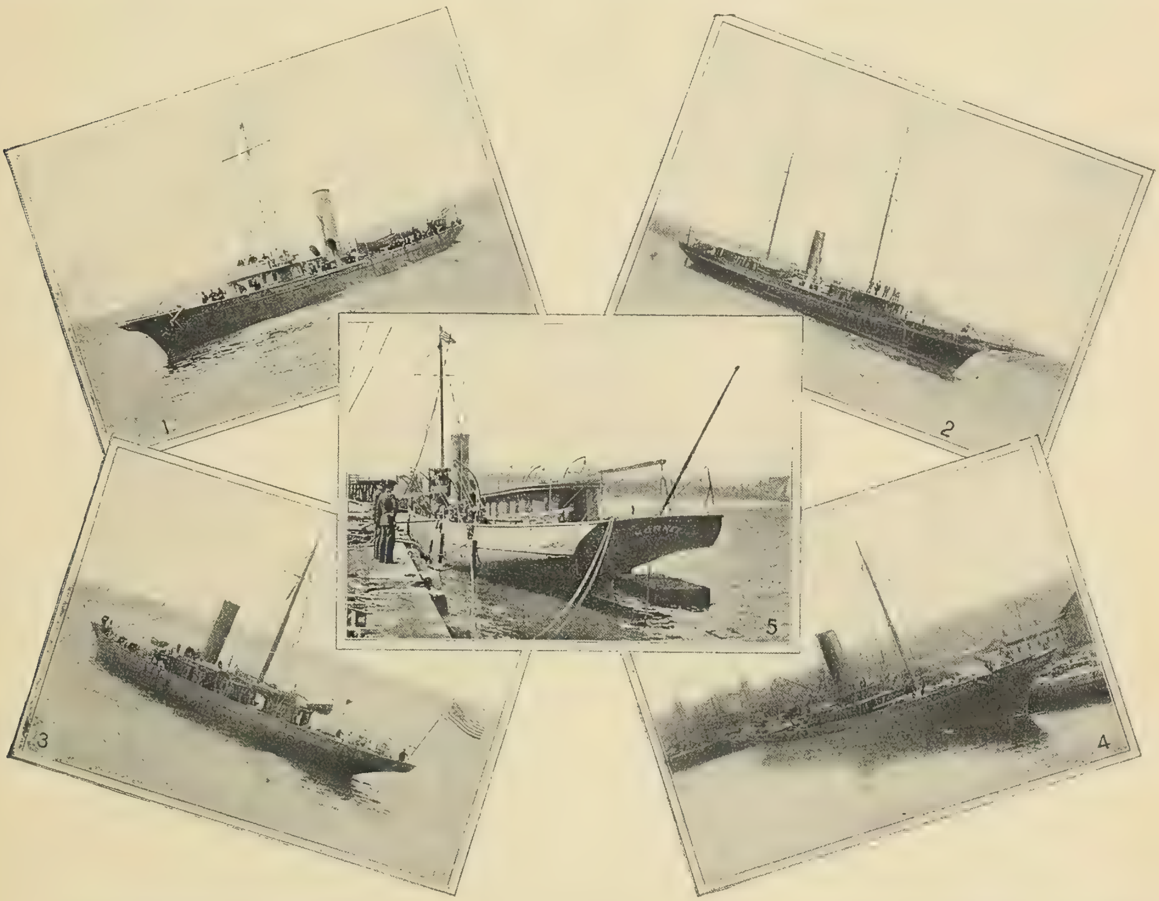
The possibilities of the yacht fleet at the present time for conversion to war uses were, even from a theoretic standpoint, far from promising. Many of the vessels were ill-fitted in model for real service at sea; there was a lack of displacement for the added weights of armament and ammunition, of berthing space for crew, of bunker space, and suitable locations for magazines. The nominal speed, in many cases low in itself, was not realized even in smooth water, and in a sea there was a serious loss of the average working speed. There was no protection, no distilling apparatus; the capacity of the water tanks was generally inadequate, and the decks were not designed to withstand the shock of the guns. The draught as a rule was greater than was necessary or desirable. The nature and extent of these defects were fully realized at the outset, but under the circumstances there was no other course but to take the yachts as they were and to make the best of them. All things considered, they have done their work quite as well as was to be expected; they have served a certain necessary purpose, and they were capable of doing even more had it been required of them.

It is impossible within the limits of the present paper to discuss the auxiliary fleet as a whole; but to those of us who have followed the discussions of this society year by year the experiment must be an

to include a type of small auxiliary indicated by the yacht, but not now in existence in this country.

The present use of the yacht fleet being confessedly but an emergency measure, the question naturally suggests itself as to whether such a course would have been necessary had our Navy been theoretically complete in all its branches; notably, had the gunboat and torpedo arms, instead of being exceedingly weak, been developed to the same extent as in other navies?

This question may at once be answered in the affirmative, for the reason that none of the vessels of the gunboat or torpedo boat types are adapted for the special service demanded of the converted yachts. The high speed which is the leading motive of tor-



1. U. S. S. Hist, formerly S. Y. Thespia. *2. U. S. S. Stranger, formerly S. Y. Stranger.*
5. U. S. S. Hornet, formerly S. Y. Alicia.
3. U. S. S. Gloucester, formerly S. Y. Corsair. *4. U. S. S. Scorpion, formerly S. Y. Sovereign.*

interesting one. The lessons to be derived from it are, first, the necessity for timely preparation in the speedy building up of an adequate navy; and, second, that to be done properly, this work must proceed for a term of years according to a comprehensive and systematic programme, completed in advance and carried out as nearly as possible without change through successive administrations.

The detail of the auxiliary fleet now under consideration, the yacht division, has, as I shall endeavor to show, a special lesson of its own; that the naval programme may be advantageously extended

pedo boat design is not only needless for the work now under discussion, but entails the loss of many essential qualities. Incidentally, it may be observed, there has been, with the exception of one yacht, Mayflower, no attempt to convert the yachts into torpedo boats; and had there been enough torpedo boats at hand for this service, the only available crews, largely made up from the Naval Militia, would have been unfit to handle them.

Assuming, then, that however perfect the torpedo arm may be, there is still a distinct field of usefulness for something of the yacht type, we come to the question discussed at the first meeting of this Society in 1893, of the policy of reliance upon the pleasure fleet as a regular means of defense in the future.

The suggestion has been made in this connection that some scheme of co-operation between the Government and individual yacht owners might be put into practice whereby, in return for certain privileges or compensations on the part of the former, the latter might be induced to plan any new yachts with a direct view to their conversion to war uses. The objection both to this method of procedure and to the general policy of reliance on the yacht fleet are very strong. On the part of the Government, the only effective inducement to be offered to the owner must be in some form of subsidy, a sort of special legislation which is practically impossible. On the part of the owner, his personal requirements, to say nothing of the wishes of his captain, his wife, and his friends, are directly opposed to those of the war vessel. There is, it is true, a common ground whereon the owner and the Government might come together to mutual advantage in demanding the essentials of good design, a seagoing model, fair working speed, ample bunker space, etc., but in too many cases these are but secondary to the demand for spacious saloons and lavish display of furnishings. To the owner who is willingly paying a very large sum for mere luxury and elegant appointments, the Government can offer but slender inducements to make his vessel a ship first and a palace afterward; or, when completed, to loan her for a time as a practice ship, as has been suggested as one feature of the scheme.

Unless very much more can be done in this direction than now seems possible, the experience of the present year is such as to indicate that the purchase and conversion of yachts is in every way undesirable as a permanent feature of naval policy. The defects of the existing fleet have been already indicated; many of them are mere matters of faulty design due to the haphazard methods that have thus far largely prevailed in this country, the owner leaving everything to his captain, who in turn deals directly with a builder. This class of defects will largely disappear as soon as the American yacht owner awakens to the appreciation of the importance of the trained specialist, the yacht designer, in the field of steam yachting as he has long since done in that of the sailing yacht. At the same time the good qualities of a perfect steam yacht are not of necessity such as to make her an ideal picket or patrol boat; and of the fleet available at any future time for conversion, many will be found to possess positive bad qualities, as in the present case.

As a matter of permanent policy, however, the question of the efficiency of the converted yacht is but secondary to that of the cost, always a controlling one in a naval programme. The circumstances attending the purchase of yachts for this purpose are necessarily such as to keep the price at a fair figure, and this price represents a large amount of furniture and decoration which is worse than useless, as its very removal entails some expense. Apart from this waste, the yacht needs to be strengthened for gun mounts, etc., and remodeled in all the internal details. When the emergency is passed and she is no longer needed, her value as a yacht will have seriously depreciated, and the work of reconversion must be far more costly than that of the first change, as its details are reversed. Where the furnishings were hastily stripped at a mere cost of labor, new ones must be purchased and put in place; where spars were simply sawed off, new ones must be made and shipped; and in place of a plain coat of lead color over everything, regardless of appearance, the entire structure must be scraped and redecorated by skilled artisans. When the present experiment has reached its final stage in the sale of many of the yachts, and the result is reduced to plain dollars and cents, there will probably be little room for doubt as to the unprofitable nature of the work.

While the actual co-operation of the Government and the yacht owner is hardly practicable, each may study with profit the lesson now before them. It is obviously to the interest of the Government to encourage the building and use of yachts; apart from the indirect advantages of a national pleasure fleet, there is always the possibility of an occasion like the present, when the larger vessels must be depended on as a *dernier ressort.* While nothing can be done in the way of direct financial aid, it is a wise and sound policy to encourage yachting by the removal of all unnecessary and oppressive regulations.

On the part of the owner, it must be apparent to him now, if never before, that his interest lies directly in putting his money into a vessel that as far as possible possesses the prime essentials for conversion to war use. It may happen, as in this case, that the opportunity to sell her at a fair figure is coincident with a temporary inability to use her on account of war. How far he can go in the compromise between his individual requirements and adaptability for conversion is a question to be settled with his designer; but he will hardly fail to realize that it is too important a matter to be disregarded entirely, as it has been in the past.

A careful study of the history of the yachts in the present war will show two important points: first, the theoretic value of vessels of the yacht type; and second, the limited extent to which the yacht fleet as a whole has realized in practice its theoretic efficiency. The work demanded and in part accomplished by the yachts is not properly within the field of either the gunboat, the destroyer, or the torpedo boat. The former is too large; the torpedo vessels, of all classes, are designed mainly for a speed which not only is absolutely unnecessary for this special work, but is obtained through the sacrifice of essentials.

The gunboat class in the new Navy had its origin in the Petrel, built in 1887, of 850 tons displacement, 11 ft. 7 in. mean draught, and 11.5 knots speed; a vessel now notable from her part in the battle of Manila Bay. The development of this class since then has been entirely upward, to vessels of 1,700 tons displacement; and no attempt has been made to carry it downward from the Petrel. Useful as they are, the gunboats now in service and the new ones under construction are unfitted by their size for the work assigned to the yachts.

So far as the torpedo boat is concerned, the present war has been devoid of results; not only is the question of the true relative value of the torpedo fleet as much an open one as it was a year ago, but false lights have been thrown on it (through the poor performance of the Spanish destroyers, and also the good work of the converted yacht Gloucester) which are calculated to mislead, at least the popular mind. It cannot be too strongly stated that the idea, quite widely prevalent, that one converted yacht is the equal of two of the modern torpedo boat destroyers, is entirely erroneous. The destroyer and torpedo boat are to-day quite as formidable as they were a year ago, quite as essential, and with a wide field of usefulness on which nothing of the yacht type can intrude. At the same time, their limitations are numerous and well defined; they are necessarily most expensive and delicate machines, lacking protection, armament, bunker space, and crew accommodation; they demand special picked crews, whose endurance is severely tested in comparatively short trips at sea; and they are at all times liable to speedy deterioration. The value of each individual boat depends mainly on the spirit and training of her crew and her excess of speed above others of her class. Had there been at hand this spring an ample fleet of torpedo boats, they would have been of but little use for the reasons that the trained crews to man them were lacking, and the men who were available, largely from the Naval Militia, were incapable of handling such delicate tools.

The work of the yachts, their success and failures taken together, with the work of other small craft such as tugs, lighthouse tenders, etc., impressed into the same service, seems to indicate the desirability of the creation of a new type of small auxiliary not at present recognized on the Navy list. The controlling feature of design—the speed—may at the outset be placed at a moderate figure for this era of increasing speeds, not over 18 knots. This, however, is not to be measured by the conventional yacht standard by which an 18 knot steam yacht takes the wash of a good 12 knot tug, but means a reasonable approach to the designed speed under ordinary service conditions at sea, and the ability to keep with the fleet even in bad weather. The model should possess seagoing qualities of the highest class; the draught should be limited to 11 or even 10 ft. as a maximum; the construction should be durable, with ample scantling both to carry the armament and to insure a long life with care in lying up; the engines should be strong and reliable, the bunker space as large as possible, and, as deck and side protection will probably be impracticable, especial attention should be given to the waterline protection of machinery and magazines through their location and the disposition of the bunkers. The accommodation should include healthy and comfortable quarters for a proportionately large complement of officers and crew for an indefinite time, and the armament should be comparatively powerful, with the guns more advantageously located than is possible on a yacht. Special provision should be made for magazines, ammunition hoists, distilling apparatus, and minor auxiliaries. There should be no sails, and no spars except the single military mast, and in all cases torpedo tubes should be excluded. Profiting by one serious defect of the yachts, special attention should be directed to the disposition of space in holds and bunkers so that it may be utilized to advantage without a material change of trim.

The intended uses of this class call for three sizes: for sea work, as despatch boats and tenders, and for picket duty, vessels of not over 800 tons displacement, about the size of the Gloucester and Scorpion, the draught not exceeding 11 ft. in a single screw boat; twin screw boats of this size with draught reduced to 9 ft. would be very serviceable, as proved in the present case, for harbor and river work. The next size to be of about 400 tons displacement, about the size of the Hist, Eagle, and Hornet, twin screw vessels of 7 to 8 ft. draught, intended for sea service as pickets. The third size, for harbor patrol service, to be of about 200 tons and 6 ft. draught, designed for smooth water, carrying a light armament and limited supply of coal. A speed of 15 knots would suffice for this service, but they should be capable of towing a vessel.

The requirements here set forth are in a general way but the theoretic qualities of the converted yacht, not fully realized now in any one vessel, but easily obtained in a special design. To the specialist in torpedo boat design or to the yacht designer, the problem would be a simple one. On the one hand the demand for very high speed, approaching 30 knots, with its egg shell construction and numerous limitations, is entirely eliminated; and on the other the numerous and conflicting requirements of the private owner as to amount and disposition of space are replaced by fewer and simpler ones. A vessel of this type could be built for far less than either the torpedo boat or the converted yacht; she would fulfil her own special mission, covering a very wide range of usefulness, better than either; she could be handled to advantage by the average crew, not necessarily experienced men; she could, when not needed, be laid up for an indefinite time, ready for service at a few days' notice; and when thus laid up she would not be subject to the double deterioration of the torpedo boat; physical in the actual disintegration of her light frames and plating, and technical in the outbuilding by vessels of newer design and higher speed. As practice vessels for the Naval Militia for short intervals in the summer, a purpose for which it has been suggested yachts might be borrowed, these vessels would be superior to either the yacht or the torpedo boat. They would carry a larger number of men than the torpedo boat, their armament of 4 in., 5 in. and 6 pounder rapid fire guns would be better suited for practice than the two extremes of the torpedo and the 1 pounder; and while the larger sizes would be capable of practice cruises at sea, the smaller with their limited draught would be well adapted for such work as the exploration and study of local waters, as now carried on by the Naval Militia.

With suitable designs once completed for each size of vessel in the class, there would be no necessity to modify them with each new improvement that gives speed; and the attention of the designer might be concentrated upon the perfecting of details and such a reduction of engines and other parts to established standards as would minimize the cost of construction, and also make it possible to add to the class very quickly in the case of an emergency.

An examination of the smaller types of gunboats in use by other nations would disclose many interesting points; but it is not necessary to go outside the immediate experiences of the past six months for several important conclusions. The conditions of coast defense, as thus indicated, involve certain work which is not within the legitimate field of the existing gunboat class, or of the high speed torpedo boat; and which can only be done imperfectly and at great expense by means of the conversion of the steam yacht. A special class of vessel fully fitted for this work can be constructed at a comparatively moderate cost; and, once provided in sufficient numbers, can be laid up for an indefinite time in a condition for almost immediate use.

The developments by Signor Marconi in wireless telegraphy have excited a considerable degree of enthusiasm in marine circles, and experiments have already been made on the Great Lakes of this country, in the Italian Navy and elsewhere, with a view to adapting Marconi's apparatus to the transmission of signals between ship and ship and between ship and shore. Clearly intelligible signals have been transmitted 1 1-2 miles on the Great Lakes and between South Foreland Lighthouse, England, and the French coast. M. Pasqualini, chief electrician of the Italian Navy, is reported as having developed a modification of Signor Marconi's apparatus by means of which signals were transmitted without trouble over a distance of 24 miles. All of the apparatus thus far devised, however, involves the disadvantage of extreme delicacy of adjustment, and for long distances (5 miles and upward) inconveniently long vertical conductors must be carried up into the air. M. Pasqualini's experiments seem to indicate that the principle is electromagnetic induction, pure and simple.

AMERICAN SCHOOLS OF MARINE ENGINEERING AND NAVAL ARCHITECTURE.

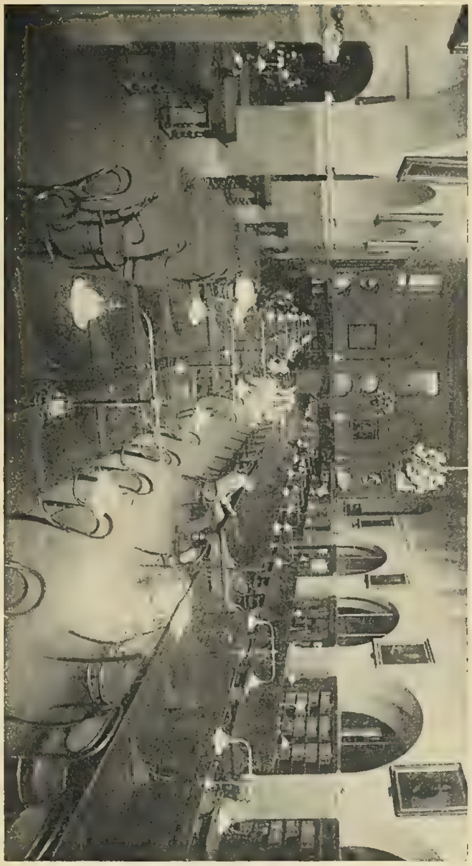
SCHOOL OF MARINE CONSTRUCTION, SIBLEY COLLEGE, CORNELL UNIVERSITY, ITHACA, N. Y.

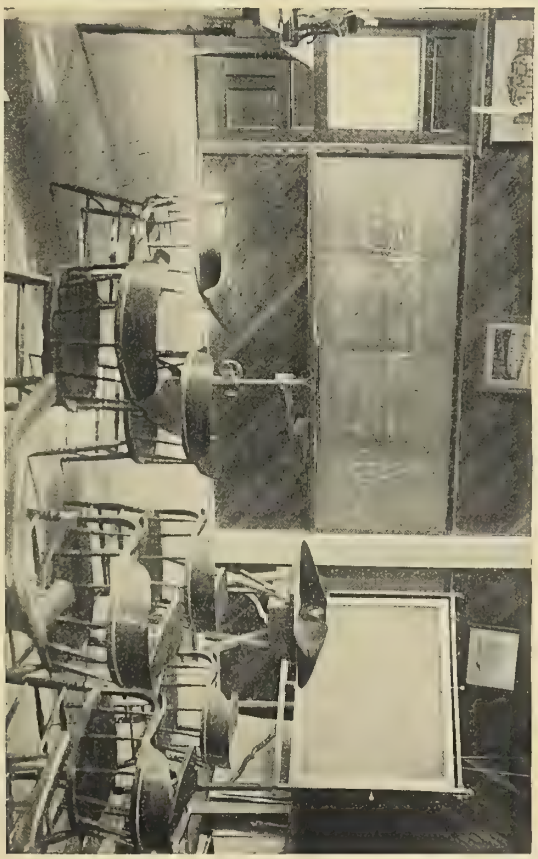
A Comprehensive Account of the Special Instruction in This Branch of Engineering Given at This American University—Widely Famed for Its Courses in the Mechanic Arts.

In the beautiful lake region of western New York there is probably no more picturesque location than that occupied by Cornell University. As the train, which carries the visitor to the college city of Ithaca, suddenly rounds a curve the buildings of the famous University on the hilltop come into view; then, a few rods farther on, the valley opens out before him, with the little city in the foreground, and beyond lies beautiful Lake Cayuga, narrow because its length is lost in the horizon, and bordered by green hills which slope gently to the water's edge.

VIEW OF THE CAMPUS, CORNELL UNIVERSITY, IN MIDWINTER.

Ithaca is a typical college town, quiet and reposeful, with a dignity which is the result of a sense of proprietorship in a great American university. Cornell University has not the history behind it which other universities can take pride in, but it is probably fortunate in this, as can be readily understood. The doors of the University were opened to students in 1868 as the representative in New York of institutions incorporated under the general provisions of the Land Grant act of 1862. By the terms of this act the leading object in institutions taking advantage of its provisions should be to teach such branches of learning as are related to agriculture and the mechanic arts. Due to this requirement of the Act of Congress,





Library Building Cornell University.
Interior of Library—General Reading Room.

Sibley College Buildings.
Recitation Room, Marine School Sibley College.

EXTERIOR AND INTERIOR VIEWS AT CORNELL UNIVERSITY.

made more practicable by the generous gifts of the late Hiram Sibley, instruction in the mechanic arts became from the start one of the leading features of the institution. Seeing that the mechanic arts as now practised are the outgrowth of modern scientific effort, the advantages of building up an institution on modern lines, and with modern ideas only to be consulted, are very apparent. It was an act of creation rather than evolution, and in the material respects of location, convenience and adaptability to modern ideas, there was the grandest opportunity for an intelligent disposition of things, undisputed by tradition, precedent or vested rights.

After its foundation the college work, so far as mechanic arts were concerned, carried along upon the original lines until the year 1885, when the various departments concerned in this work, which from the first had been known collectively as Sibley College, were organized more distinctively upon an engineering basis, with the present Director, Dr. R. H. Thurston, in charge. The experience of Dr. Thurston as an officer of the U. S. Naval Engineer Corps during the Civil War, and later as a teacher at the U. S. Naval Academy, naturally led him to appreciate the importance, especially to American mercantile marine interests, of an oportunity for the special study of Marine Engineering and Naval Architecture on the part of those who were to be charged with the duty of designing, building and operating the American mercantile marine. The original inception of such a school at Cornell University may therefore be said to date from 1885, when the present Director of the College took charge.

The broad policy of the administration of Sibley College has constantly been: To provide, not only for the proper undergraduate courses in Mechanical Engineering, but also to establish, as they may be called for and as the progress of the University may permit, a system of advanced schools of special branches of Mechanical Engineering.

The time seeming ripe for such action, the School of Marine Engineering and Naval Architecture was organized as the first of such special schools, by order of the Board of Trustees, October, 1890.

SCHEME OF INSTRUCTION, ETC.

The object of this school is to provide courses of instruction and opportunities for research in such special branches of engineering as relate to the design, building, powering and propulsion of vessels of any and all types. Such courses naturally fall under the heads: (a) Naval Architecture. (b) Marine Engineering.

These two subdivisions are closely inter-related, and of the courses of study offered, many are common to both. Outside of these each branch is specialized in its own direction, the Naval Architect being, of course, more especially interested with the ship, and the Marine Engineer with the engine and the application of its power to the propulsion of the ship.

The instruction in the courses in Marine Engineering and Naval Architecture is given by Professors Durand and McDermott, who have held their present positions from the foundation of the school, and whose previous professional training and practical experience as a preparation for such work cover periods of from ten to twelve years each, for the former in the U. S. Naval Engineer Corps, and for the latter as Naval Architect to one of the leading shipyards on the Clyde. These professors devote their entire time to the work in these subjects, and specially aim to make the instruction thoroughly practical in its nature, while at the same time due attention is given to the theoretical or scientific, and to the development of a close relationship between the two, thus laying a broad foundation for the intelligent study of the subject both as a science and as an art.

The instruction is given largely by lectures, or by lectures as supplementary to mimeograph notes and text-book. Frequent quizzes and occasional written essays on the subject matter of the lectures insure a proper understanding of the subject on the part of the pupil. In the course in Marine Engineering the descriptive study is based chiefly upon a large collection of blue prints representing in detail the best practice in mercantile and naval designs, while a course of auxiliary reading is assigned, including a half dozen of the best modern books treating of the subject. Much of the time of the student is spent in "application" work, consisting of computation and drawing, all of which is under the personal direction and frequent supervision of his instructor in the subject. The methods of instruction and the courses of study, hereafter enumerated in this article, are the result of a continuous development during the past eight years.

That special training in Marine Engineering and Naval Architecture is of value in the modern shipyard seems to be proven by the fact that most of the students thus trained have found employment in their chosen field, either in private shipyards or as assistant draughtsmen under the Navy Department Bureau of Construction and Repair. Some have already reached positions as chief draughtsmen, and in all the leading yards of the Atlantic coast and the Great Lakes representatives may be found, many of whom are doing work in connection with the more important recent designs, both for the Navy and for the American mercantile marine.

The university year, which is the same for all the colleges, runs from about Sept. 25 to June 15, and is divided into three terms, with about a week's intermission between, at Christmas and at Easter.

The University provides no dormitories, except for it's 200 women students, and the men find homes in the various boarding houses which abound on the side hill between the Campus and the business part of the town, or in the various Greek letter fraternity lodges, of which there are nearly thirty in active life.

That "All work and no play makes Jack a dull boy" is nowhere more thoroughly believed than at a modern university, and the long, almost unbroken, history of victories in boating standing to the credit of Cornell, together with the good showing which her teams have made in base ball, foot ball, and other intercollegiate sports, show that these things receive their due attention as well as Greek and Mathematics, Science and Engineering, or Law and Psychology.

The situation of Cornell University in a small town in one of the most beautiful and picturesque parts of

Sibley Students in the Foundry.
Main Machine Shop at Sibley College.

Students at Work in the Joiner Shop.
Forge at Sibley College.

PRINCIPAL WORKSHOPS FOR PRACTICAL INSTRUCTION AT CORNELL UNIVERSITY.

the lake region of western central New York gives it special advantages from the educational standpoint. The location on the crest of a hill, about 400 ft. above the city of Ithaca, and overlooking Cayuga Lake on the north and the city and distant hills on the west and south, furnishes a never failing source of inspiration in itself. The open country lying back of the Campus and the lake within easy reach on the north give abundant opportunity for physical exercise and development, while in the town is to be found everything needed for comfort and convenience, without the distractions which are necessarily found in larger cities.

But to return to the School of Marine Construction, it is a significant sign of the times that the ship builder, the ship owner, the political economist and the financier are all agreed that the American mercantile marine is sadly in need of new life and vigor, and that its rehabilitation is nothing short of a national duty; though they are by no means so well agreed as to the means necessary to the accomplishment of this purpose. All will agree, however, that one of the important means to this end is a shipyard wherein with the minimum of expense, both in time and money, there can be produced with certainty a ship which shall, on the least expense for operation, fulfil the various specified conditions of design. In the present condition of the art of shipbuilding, and with active foreign competition in view, such results are not to be obtained by haphazard methods, and herein lies the great responsibility, and yet opportunity, of the School of Marine Construction. It is to the students of such institutions that the country must look, largely, for the restoration of America to the leading position among shipbuilding nations.

COURSE OF STUDY.

The course of study at Cornell recognizes the fact that the Naval Architect and Marine Engineer must have the broad training which lies at the foundation of all branches of the engineering profession, and that he should have, in addition, much of the special training which relates to branches other than those in his own chosen field.

With this end in view, the first three years of the course are, with slight exception, the same as for the regular training in Mechanical Engineering. During the third year the Naval Architect begins to specialize in ship drawing, while the Marine Engineer continues the regular course. During the fourth year a part of the work for both is the same as in the regular Mechanical Engineering course, while a part is distinctively marine. The four years' course thus planned leads to the degree of M. E., and constitutes a strong course in Mechanical Engineering, with sufficient specialization in marine work to enable the student to appreciate intelligently the leading problems in this field.

The amount of time which the student may devote to drawing, design, and similar work representing the application of the lectures is limited only by his ability and the time at his disposal. A certain amount of such time is required, but more may be given with corresponding benefit, if the time is available. To take advantage of this provision many students, by working in the shops during vacations, and in various other ways, work ahead of the course and devote the additional time at their disposal to the subjects in which they are specializing. In this way it is not uncommon for a student to practically double the amount of time available for drawing, design and similar "application" work.

In addition to this work, given in the undergraduate course, a post graduate course is given, in which the student gives his whole time to marine work, and in which the undergraduate lines of study are carried on, and additional work of an advanced character is introduced. The student who successfully completes the graduate year should be as well fitted for an intelligent introduction into the practical work of his profession as he can hope to be outside of the school of actual experience. The degree of M. M. E. may usually be taken at the end of a year's post graduate work.

In the foregoing the course in general is outlined, and now the entrance requirements call for consideration, as well as the subdivision of time in the course, and a synopsis of the marine course will also be of special interest.

ENTRANCE REQUIREMENTS.

The following subjects are required for admission: English, Physiology and Hygiene, History (the student must offer two of the four following divisions in History: (a) American; (b) English; (c) Grecian; (d) Roman), Plane Geometry, Elementary Algebra, Solid Geometry, Advanced Algebra, Plane and Spherical Trigonometry and *either* French or German.

The undergraduate course as at present specified requires about 226 hours of university credit, distributed over four years of three terms each, a term consisting of about twelve weeks' work. One hour of university credit means one lecture or recitation per week for a term. In counting drawing and shop work, three hours, and in counting laboratory work two and one-half hours per week for a term are required for one hour of credit.

The distribution of the work for the marine course may be summarized in the following table, which is again represented graphically in the diagram printed hereafter.

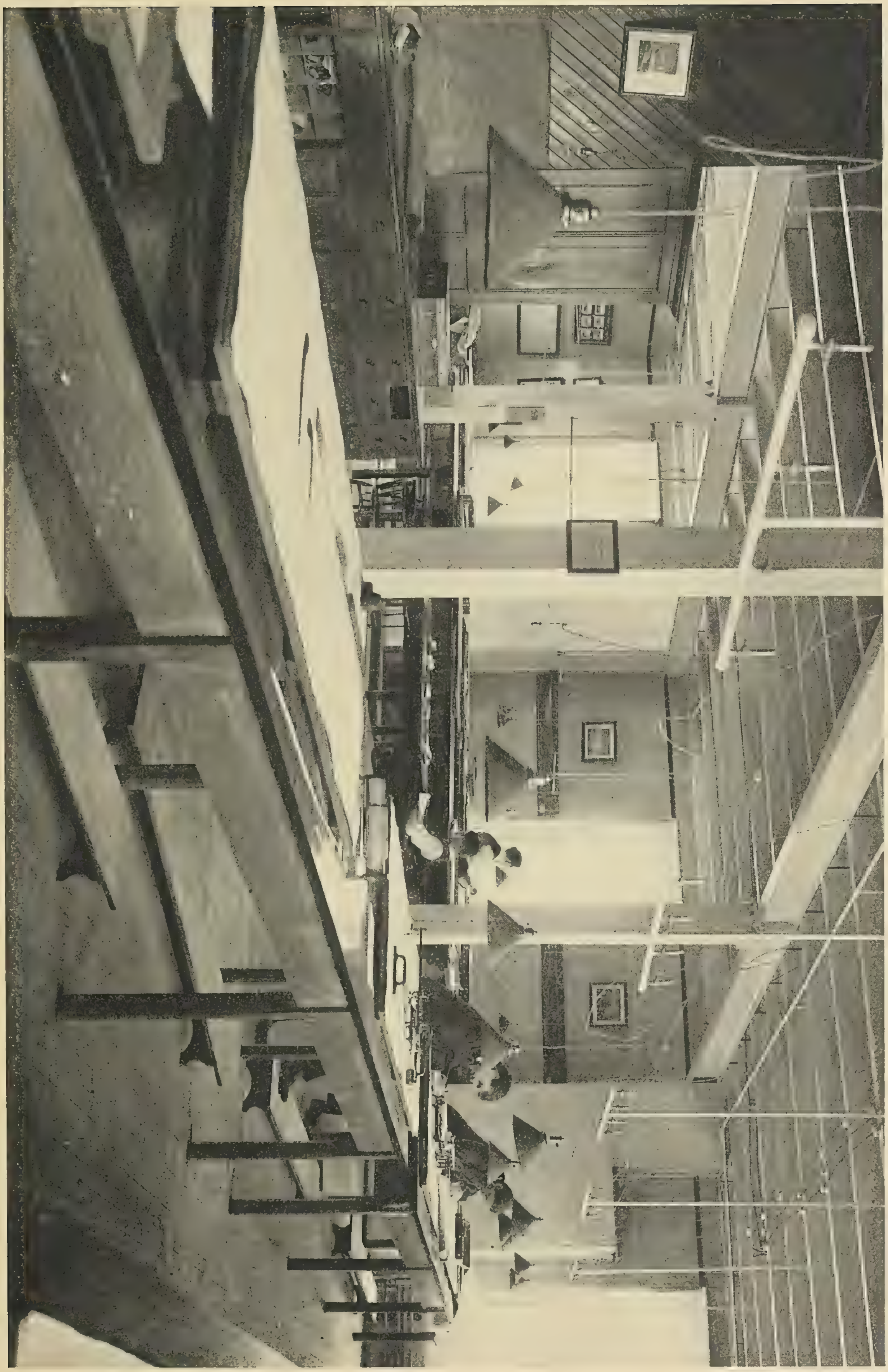
SUBJECT OR ALLIED GROUP OF SUBJECTS.	HOURS OF CREDIT.	PERCENTAGE SUBDIVISION.
(1) Mathematics and Mechanics, including Descriptive Geometry	36	16.0
(2) Modern Language	9	4.0
(3) Physics and Chemistry	36	16.0
(4) Drawing	15	6.6
(5) Electrical Engineering	10	4.4
(6) Mechanical Engineering (general)	41	18.0
(7) Shopwork	31	13.7
(8) Marine Courses	48	21.0
	226	

In the graduate year the time is practically all spent in marine work, or in work closely allied to it, along advanced lines, as indicated in the synopsis of the studies below.

Synopsis of Courses.

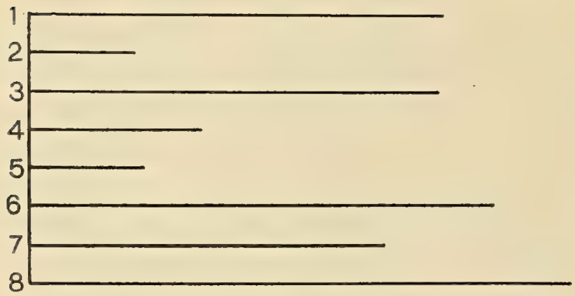
NAVAL ARCHITECTURE.

The leading features of this course are as follows: Methods of approximate integration and their appli-



DRAUGHTING ROOM OF THE SCHOOL OF MARINE CONSTRUCTION AT SIBLEY COLLEGE, CORNELL UNIVERSITY, ITHACA, N. Y.

cation to the calculations arising in naval architecture; theory of the planimeter and integrator; integral curves and theory of the integraph; the various form coefficients, their significance and relationships; computations for displacement, tons per inch, centers of buoyancy, metacenters, moment for change of trim, wetted surface, etc. In connection with these the usual curves and graphical representations are laid down. Careful attention is given to the relationships



DISTRIBUTION OF WORK FOR MARINE COURSE.

existing between these various geometrical quantities, and a thorough foundation is laid for the intelligent study of any portion of the immersed body so far as may relate to areas, volumes and centers of gravity.

Following these subjects the foundation is laid for the theory of stability, and representative methods in use are explained and illustrative computations are made.

The theory of the strength of the ship, considered as a complex girder, is developed in detail, methods of computation are derived, and actual computations are carried out in the work under the course of Ship Construction and Design.

The subjects of resistance, propulsion and powering are considered in great detail, and the most approved methods are given and illustrated by the results of experimental research.

Special attention is paid to the laws of comparison and to methods of analyzing the results of experimental and trial data.

The theory and design of the screw propeller receive careful attention, and the most approved methods are illustrated by numerous examples and illustrative problems.

In the advanced course, in addition to new subjects, several topics already studied are taken up and studied again in a more general way or from a more advanced standpoint, the object being the more complete preparation of the student through such work for the intelligent treatment of the various problems which continually arise in both the science and art of marine construction. The work consists partly of lectures, partly of directed courses of reading, and partly of personal study on the part of the student under the direction and aid of the professor in charge. Among the topics thus studied are these: stability by special methods, advanced stability theory, water in bilged compartments, added or subtracted weights, inclining experiments, liquid lading, launching conditions, wave motion, oscillations of ships in still water and waves, trial trips and their analysis, theory of the rudder and of gyrations, special problems in stability, stress and strain, resistance, propulsion.

SHIP CONSTRUCTION AND DESIGN.

This course, which extends throughout the year, opens with a series of lectures on ship building, in which the innumerable details of construction of steel and iron vessels, their fittings and equipment, are fully described.

Starting with a description of the work involved and the methods employed in the laying down and fairing of the lines of a vessel in the drawing room and mould loft, the rules of the leading registration societies or associations—*American Bureau of Shipping, United States Standard, British Lloyds, Bureau Veritas, etc.*—for the construction and classification of vessels are next taken up, the scantlings or sizes of the different parts of the steel and iron structure of vessels, and the mode of procedure in obtaining them peculiar to each society, are carefully examined and compared in detail.

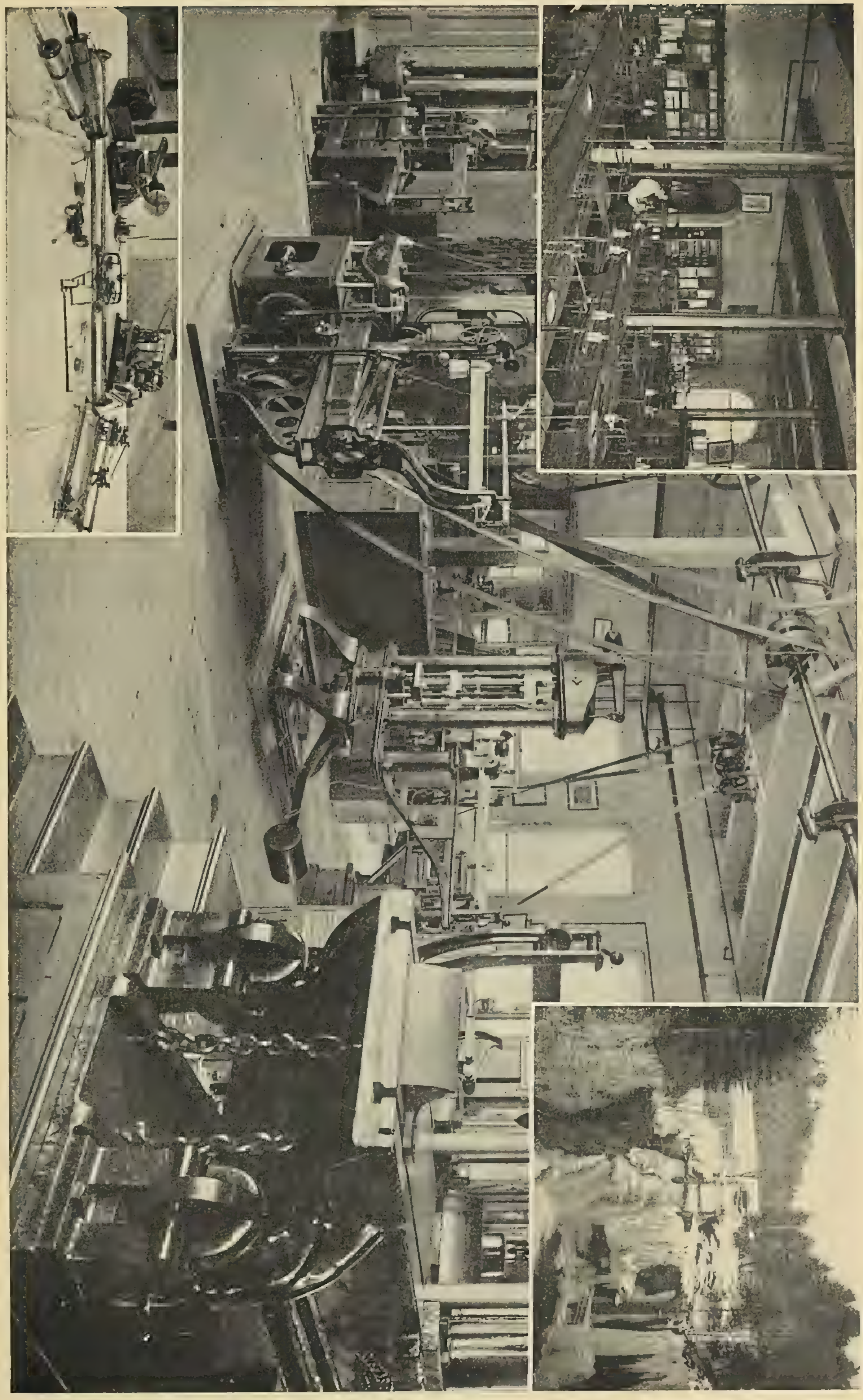
Following this the lectures deal with the different operations in the shipyard, connected with the preparation, assemblage and fastenings of the various parts of the ship in all the stages of construction, including the preparation of the scrive board, preparing the ground in way of building slip, laying of keel blocks, laying of wood decks, ceiling, building of houses for passenger and other accommodation, fittings, cementing and painting. Special attention is devoted to a description of the leading types of ship machines for the handling of cargo, anchor gear, steering gear, pumping, drainage, ventilation, lighting, systems of telegraphy, life saving appliances, and other details of general equipment and outfit. The application of steam, compressed air, electrical and hydraulic power to the above appliances is dealt with in the general discussion.

The series of lectures concludes with a detail of the operation of launching, docking, placing machinery, masts and other heavy weights in position, and the general completion of the vessel.

Supplementary to and illustrative of the work embraced in the above lectures, the following drawing room exercises are performed as far as time and skill of the student will permit: Laying down and fairing a set of lines of a vessel to fulfil given geometrical conditions. Preparation of mid-ship section of same vessel, showing scantlings according to the rules of the aforementioned registration societies. General arrangement plans showing disposition of machinery, cargo holds, coal stowage, passenger and crew accommodation and general equipment. Computations of the different geometrical quantities for verification in comparisons with those stated in the given conditions.

In performing these exercises close personal supervision is given and the salient features of the work in general application are pointed out and discussed.

Having become familiarized with the art of ship construction, and gained a thorough knowledge of the fundamental principles upon which the science is based, from his studies in Naval Architecture, which are carried along on parallel lines, the student is prepared to take up the problem of Design.



Experimental Canal Above the Falls, Now Under Construction.

A View of the Machines in the Testing Laboratory.

One of the Chemical Laboratories.

Measuring and Calculating Instruments Used in the Marine Course.

SOME OF THE FACILITIES FOR EXPERIMENTAL WORK AT CORNELL UNIVERSITY.

This division of the course is dealt with in a series of lectures under the following heads:

Weights: Hull, outfit and equipment; machinery; fuel; passengers, crew, and their effects; stores, provisions and fresh water. The most approved methods of estimating the above weights are carefully considered.

Dead Weight and Stowage: Of cargo of different classes peculiar to the various trades are fully dealt with, as also that of coal, oil and other fuels.

Speed and Power: The subject of speed is given special attention, and the relationship between speed and power is discussed from the designer's standpoint.

Stability: The question of stability, as found in every day practice, receives careful treatment. The determination, experimental and otherwise, of the centers of gravity of vessels, their machinery and loads in different conditions of service, are explained and discussed.

Trim: The trim of vessels is dealt with in similar detail.

Safety: The considerations which are involved under this important head are fully examined—watertight subdivision, duplication of machinery, fire annihilation and pumping, freeboard, stability, and other branches of the subject are passed in review, and the part which each takes in the general solution of the problem is carefully considered.

Strength: The strength of a ship, in its separate details and as a completed structure, is taken up and critically examined.

Finances: The cost of production is next taken up and different systems of estimating the cost of vessels, their machinery and outfits complete, are explained in detail; the effect which the several conditions have upon the cost are carefully pointed out from both the ship builder's and the ship owner's point of view.

Having passed in review the underlying principles and conditions of design in detail, under these heads, the concluding lectures deal with the selection of the most suitable dimensions to fulfil the conditions, in whole or in part, as they are met with in the ordinary demands of the commercial marine.

In the drawing room the work embraced in these lectures is applied and illustrated, each student preparing a completed design to fulfil a given set of conditions.

As a conclusion of the completed course, one or more lectures, as may be found necessary, are given upon the organization and administration of ship and engine building establishments, considered technically and financially.

In the advanced or post graduate course in ship design the student progresses along lines of original thought and investigation.

MARINE MACHINERY.

The subject is studied first from the descriptive standpoint, illustrated by large numbers of drawings and prints representative of the best modern practice in both naval and mercantile designs. The various types of marine boilers, including the various forms of tubulous or water tube boilers, are examined and their peculiar characteristics, advantages and limitations are pointed out. Special note is taken of corrosive and deteriorating causes, and the best means of prevention. Attention is also given to piping, the various methods of forced draft, special fuels, boiler auxiliaries, evaporators, feed-water heaters, etc., with hints on general boiler care under the conditions of use. The influences of the peculiar conditions of marine boiler practice upon the general principles of boiler design are then examined, coupled with analyses of the designs of boilers representing the best practice, and followed by designs of an original character by the student.

In a similar manner a study is made of the peculiar conditions under which the marine engine is obliged to work, and of the advantages and disadvantages of the different types and forms. The influence of these peculiar conditions on general engine design is noted, and analyses are made of several designs representing modern practice. These are followed by numerical designs of an original character for both main engine and auxiliaries, supplemented by actual drawings as far as the time will permit.

Special attention is paid to vibrations and the balancing of marine engines; the derivation of the probable indicator cards for a multiple expansion engine from the valve events and the cylinder, receiver, and clearance volumes; and the derivation of curves of turning moment and their modification by the inertia of the moving parts. In carrying out this work in design a detailed examination is made of the problem of balancing and crank effort, including the influence of inertia, using both graphical and numerical methods of computation. All valve gears are designed and the results analyzed by the aid of a specially designed valve gear model which gives accurately the movements of the various parts, and the consequent movement of the valve. For the machinery thus designed, general specifications of the whole and detailed specifications for at least a part are prepared, in order to familiarize the student with the forms and phraseology employed.

MARINE ENGINEERING.

This course is a continuation of the course on Marine Machinery, and consists of an advanced study of various special topics connected with the design, construction and efficient management of marine machinery. The designs are carried on to include detail drawings of the more important parts of the engine and auxiliaries. One or more general arrangement plans are also prepared, showing the main and principal auxiliary machinery, boilers, uptakes, smoke pipes, principal steam and water pipes, coal bunkers, store rooms, etc. Lectures are given in these and kindred topics, and special subjects for personal study and research are assigned, the better to develop independence of thought and method and acquaintance with engineering literature.

SEMINARY.

This exercise consists of a weekly meeting, in which the current technical and professional literature is discussed, with such other special topics as may seem timely. The current literature is assigned among the members of the class, abstracts of articles and notes of interest being presented at the seminary for common information and for free discussion. The object is to provide a means for keeping up with the world's progress in professional matters, and an informal meeting for the ready interchange of ideas among those interested in this line of work.

THESIS.

The subject of the graduating thesis in this school may be either the design of a ship or her machinery, or a special investigation of some particular topic in this field. If a design is chosen, an early choice of subject makes it possible to apply much of the illustrative work of the course to the thesis, thus making it more complete than it could otherwise be made in the time usually allowed.

EQUIPMENT AND FACILITIES FOR INSTRUCTION.

The school occupies commodious and well lighted quarters, consisting of drawing room, lecture room, offices and store rooms, and is well equipped with all material aids for the study of Marine Construction. Special attention is given to the varied computations which form so large a part of the work of the naval architect, and the student is drilled from the first in the use of the most approved mechanical aids, such as the planimeter, integrator, integraph, comptometer, slide-rule, etc. Especial attention is given to the use of the slide-rule in computations, the school being well supplied with "Fuller" rules, and every effort is made to give to the student sufficient practime to make him familiar with the more important mechanical aids as they may be applied in his every day work. At the same time purely numerical computations are by no means neglected, and special attention is given to accuracy and rapidity in all work of this character. In addition to these instruments the school possesses a large collection of drawings, blue-prints, and photographs representing all varieties of marine construction and serving as valuable material for illustrative purposes.

During the past eight years an effort has been made to gather into the University Library the literature relating to marine construction, both in English and in the European continental languages, and both modern and historical. As a result the library is exceptionally complete in this department, containing in addition to practically all of the modern literature many rare books of great historical value and interest.

In addition to these items used in every day instruction, attention is also called to the new experimental tank or canal, a part of the extensive hydraulic laboratory just established under the charge of the College of Civil Engineering. This canal is about 350 ft. long by 16 ft. wide and 10 ft. deep. Arrangements have been made whereby the facilities here afforded may be made available for the purposes of this school, and it is hoped that in the near future the canal will be provided with the equipment needed for special research in the fields of resistance and propulsion.

SPECIAL STUDENTS.

An excellent feature of the college is the provision for the special admission of students who are not candidates for degrees. Such students may be admitted without examination to any of the courses. They must be not less than 21 years of age, and their training and preparation must have been such as to enable them to carry on with profit the courses which they propose to take.

Under these conditions, persons who may already have some knowledge of the subject, but who may wish to acquire a more exact knowledge of fundamental principles and approved methods, or who may wish to pursue special studies on certain topics connected with the subject, may spend with profit a year or more as a special student in this work. While such students do not take a degree, they may be given a certificate of attendance, stating the amount and nature of the work which they have successfully completed. This gives a splendid chance for the *practical man* who has not had opportunity to follow up advanced theoretical work to take up such work and get the benefit of university instruction and facilities. Such a student who realizes his needs and the extent to which they must be supplied usually makes an earnest and highly successful worker.

EXPENSES.

The tuition fee for all students is $125 a year. Books and laboratory fees amount to from $25 to $40 additional. The usual cost in Ithaca of board and lodging varies from about $4.50 to $7 per week.

COLLEGE AND UNIVERSITY.

Of Sibley College in general and the opportunities for the special study of mechanical and electrical engineering as introductory or supplementary to the marine courses, an entire article might be written. The accompanying photographs, however, will furnish an idea of some features of the equipment. Of special importance for the students of Marine Construction are the facilities for the study of the properties of materials provided by the testing laboratory with an equipment of upward of fifteen testing ma-

Lake Cayuga. *City of Ithaca.* *Cornell University.*

chines of capacities varying from 300,000 to 15,000 pounds, and including the Emery hydraulic machine exhibited under government auspices at the World's Columbian Exposition. Of a similar character is the equipment of the Department of Electrical Engineering in conjunction with the University Department of Physics, whereby are afforded unexcelled facilities for the study, both theoretical and experimental, of electrical generators, motors, and of electrical apparatus and equipment of all kinds.

Much might also be said of Cornell University as a whole, with its nine colleges, some fifty departments, and a teaching force of nearly three hundred professors and instructors. Among these various departments of instruction, those of Mathematics, Physics, Chemistry, Law, and Political Economy, furnish most valuable opportunities for the study of special topics of interest to the Marine Engineer and Ship Builder. These and all other departments of instruction are open to any student in the University, under the general restriction only that his previous preparation shall be sufficient to enable him to take up the work with advantage to himself.

Two large steamships for the Morgan Line, the *El Norte* and *El Sud,* were launched last month by the Newport News Shipbuilding & Dry Dock Co. They are sister ships and will cost $600,000 each. In dimensions they are as follows: Length over all, 406 ft.; beam, 48 ft.; depth, 33 ft. 9 in.; gross tonnage, 4,665 tons. The hulls of the ships are of steel throughout, and they will have three decks. They are rigged with two steel pole masts and necessary booms for handling cargo.

DISCUSSION OF THE PERSONNEL BILL RECENTLY PASSED BY CONGRESS.

BY DAVY JONES, A. B.

The Act to reorganize and increase the efficiency of the *personnel* of the Navy and Marine Corps of the United States, or, as it is better known, the Naval Personnel Bill, having been passed by Congress at its last session and approved on March 3 by the President, a brief outline of the circumstances leading up to the framing of such a measure, particularly in its bearing toward engineering in the Navy, as well as the bill's provisions as finally enacted into law, must prove of interest.

To those who have followed the gigantic strides and wonderful development of warship construction within recent years, it will not seem strange that an organization which rested mainly on sail power as a foundation must of necessity be obsolete. Sixty years ago warships were propelled by sails alone, and there existed no necessity for Engineers. With improvements in the steam engine came its gradual application to vessels as their motive power, but only at first as an auxiliary to sails in calm weather. Later, during the period of the Civil War and for years afterward, the conditions became reversed and steam was regarded as the principal motive power and sails as auxiliary. To-day sails have entirely disappeared from our warships as a propulsive power.

With this advancement in our ships to meet modern conditions, our *personnel* in its organization on shipboard has not kept pace. The long history of the sea shows nothing so steadfast, nothing which withstands the years so firmly, as naval law and custom which govern the duties of officers and men. Although for fully half a century steam has been a growing factor in naval science, the horse power of naval vessels increasing from the maximun of 1,000 in 1864 to 21,000 in ships of recent date, and with auxiliary machinery increasing from the scant half dozen engines of the *Monitor* to 175 steam cylinders in the *Columbia* type, the organization of our *personnel* remained practically as during the Civil War.

It is true the education of Line Officers has, in later years, been supplemented by a course in engineering, since in actual service a part of their daily duty is the handling of much of the auxiliary machinery, including dynamos, turret machinery and ammunition hoists, etc. Fundamentally, however, the old method of making a sailor prevailed, and, nothwithstanding the slight engineering training given, no real effort has been made until recently to fit the *personnel* to the modern *matériel.*

Under a naval organization, therefore, which was based on the needs of days when steam played an inconspicuous part, it could not be otherwise than the varying interest of the two corps of officers—Line and Engineer—with their widely distant points of view, and ever increasing overlapping duties, should produce the conflict which has been waged between these branches of the Navy for more than thirty years. Discord was inevitable because the organization was irrational. Efficiency, as well as harmony, demanded a full recognition of the Engineer. The Line Officer, however, justly proud of the past achievements of his corps, was disposed to yield none of his military functions to the newcomer; while the Engineer, trained in the same school, and side by side with Line Officers, could not but see injustice in a system which gave him a vast responsibility in care of machinery of all types, with the control, in some cases, of half the crew, and yet refused him the right to command enlisted men, classed him as a non-combatant and denied him the military title which for centuries has been associated with the fighting man.

Some idea of the bitterness of this Line and Staff struggle may be gleaned from the writings of Governor Roosevelt, who, after appointment as Assistant Secretary of the Navy in 1896, quickly recognized the danger to a military service thus divided against itself. It was in part due to his persistent efforts that a solution of the problem was reached. He says:

> Not long after I became Assistant Secretary of the Navy my attention was called, by a number of occurrences, to the fact that there was much friction in the *personnel* of the Navy between the Line Officers and the Engineers. Its was not so much that any one officer, or set of officers, made charges against another, but that the point of view on both sides showed a state of affairs which, if allowed to continue, would certainly be detrimental to the efficiency of the Navy. It was very unpleasant to find officers of the highest standing displaying toward brother officers of a different corps a feeling of jealousy, which was emphatically unworthy of a service with such noble traditions, and of officers so single minded in their devotion to the flag.
>
> This state of affairs demanded investigation, in order to ascertain whether something could not be done to do away with the conditions that had called it into being, and to make every

officer in fact, as he already was in desire, an active helper in the upbuilding of the efficiency of the Navy.

Consultation with members of the Naval Committees of the Senate and the House revealed the fact that the trouble was chronic, and had causd serious damage to the Navy in Congress, for every Congressman who was doubtful as to the policy of upbuilding the Navy was apt to be changed into a positive foe of the Navy by this "Line and Staff" fight.

In November, 1897, the Secretary of the Navy organized a Board of Officers, with Assistant Secretary Roosevelt as President, for the purpose of considering measures calculated to promote harmony and increase efficiency in the naval service, with special reference to the Line and Engineer Corps. The Board was composed of seven Line and four Engineer Officers, and may be considered fairly representative of the two corps, a majority of the officers having been in the Navy over thirty years, while each side had one officer to represent the younger men. As the Engineers had long contended that they were not accorded a proper status in the Navy, they were called upon by the Board for a statement of their claims, and these were submitted substantially as follows:

1. The right to exercise military command over the men of the Engineer department. It will surprise civilians, no doubt, who are unfamiliar with Naval laws and regulations, to learn that such a claim as this should be necessary; but existing laws and regulations have heretofore explicitly denied the right of command to all Staff Officers, which includes Engineers.
2. The right, under proper circumstances, to command any enlisted man. With the right of command denied to Staff Officers there have been cases in which it was attempted to subordinate a commissioned Staff Officer to an enlisted man.
3. Actual instead of "relative" or "trade dollar" rank, in order that the legal right to command enlisted men should not be questioned.
4. The military title indicative of this rank, but with the name Engineer Corps added, in order that there might be no confusion with Officers of the Line, and following the custom of the Army with respect to officers of the various Corps and Departments.

The Board thoroughly discussed these several claims, and while some of the propositions were considered with a certain degree of approval, it may be said in general terms that the claims met with unanimous opposition of the Line Officers composing the Board. It thus seemed that a deadlock had been reached at the very start, since one side totally disagreed with what the other considered as vital. A solution, however, came immediately afterward in a proposition from one of the Line Officers to abolish the separate Corps of Engineers and to have all engineering duties performed in the future by Line Officers. This proposition, after several days' thorough discussion, was adopted, although it can hardly be claimed as originating with the Board, since there have been in the past many who have given close study to the personnel question and could find no other satisfactory solution. It is worthy of note, too, that the vote of the Board on such an unmatched innovation was practically unanimous, there being but one dissenting voice.

Proceeding, therefore, on the lines of amalgamating the Deck and Engineer Officers into one homogeneous corps, as the distinguishing feature, the Board framed for Congressional action a bill to bring this about with, as far as possible, even justice to all officers of both corps.

As to the reasons actuating the Board in recommending a solution to reconcile all differences by such a radical change, it is of interest to quote from the report of Governor Roosevelt, submitted to the Department soon after the Board's labors were completed. He says, in part:

As was natural, in groping about to remedy a new evil caused by new conditions, it has seemed very difficult to hit upon the right expedient. Yet in reality the remedy is simple and obvious. All that is needed is to make the Line Officer and the Engineer the same man, by throwing both corps into one; or, in other words, to do away with the Engineers as a separate corps by requiring all Line Officers hereafter to possess that knowledge, both theoretical and practical, of steam engineering and mechanics which it is absolutely indispensable for the thoroughly efficient modern Line Officer to show.

Every officer on a modern war vessel in reality has to be an Engineer, whether he wants to or not. Everything on such a vessel goes by machinery, and every officer, whether dealing with the turrets or the engine room, has to do Engineer's work. There is no longer any reason for having a separate body of Engineers, responsible for only a part of the machinery. What we need is one homogeneous body, all of whose members are trained for the efficient performance of the duties of the modern Line Officer. The midshipmen will be grounded in all these duties at Annapolis, and will be perfected likewise in all of them by actual work after grduation. We are not making a revolution; we are merely recognizing and giving shape to an evolution, which has come slowly but surely and naturally, and we propose to recognize the Navy along the lines indicated by the course of the evolution itself. . . .

On the fighting ship the fighting man must stand supreme; only he must know how to handle his tools, and must change as the ship changes, so that precisely as he once knew about sails, now he must know about engines. There can be no divided command. Only one man can exercise it; but he must be thoroughly fitted for it. It is not necessary that he should possess the manual dexterity whether of the topman or of the engine driver; but he must have passed through the training which will enable him to oversee and direct their work.

A change like that which took place two hundred years ago must take place now. As then, the sailor man who knew only how to handle a ship had to be merged in the trained officer, while the sea soldier who had once commanded his troops either ashore or afloat became also a sailor man, so now the Line Officer and the Engineer must become one. . . .

Of course, such a proposition naturally meets opposition. The old Line Officer wags his head at the thought of the new duties to be learned, just as one of Blake's lieutenants, in his fierce battles with the Dutch and Spaniards, would have wagged his head if told that he ought to know how to stand his trick at the helm or to handle the rigging; while the old Engineer Officer, untrained to military command, disbelieves in any but one of his own kind being able to acquire the knowledge of his profession. Nevertheless, the difficulties in the way of realizing the proposed scheme are in reality altogether shadowy. The Engineers are now taken from precisely the same class of men, with precisely the same ideas, as are the Line Officers, and when their duties are made those of Line Officers they will show precisely the same capacity for command. The Line Officers in turn are already of necessity continually doing more and more engineering work. Electricity, for instance, is in the Navy purely in the hands of Line Officers, who have developed it to a high degree; while the Ensigns on our torpedo boats, who are in fact, although not in name, detailed as Engineers aboard them, are having a training which guarantees their thorough efficiency hereafter in the engineering part of their profession.

In short, it is absolutely essential that the best naval officer of the future shall be proficient in engineering. . . .

To sum up, we must disregard the prejudices of the old style Line Officer and old style Engineer, precisely as two centuries ago it was necessary to disregard the prejudices of those who would have kept separate the functions of the man who fought the ship and the man who sailed her.

While amalgamation of the Line and Engineer Corps is the most radical and far reaching feature of the personnel bill, the measure embraces as well other matters of signal importance to the Navy. The essential points contained in its provisions may be briefly summarized thus:

1. Amalgamation of the Line and Engineer Corps.
2. Regulated flow of promotion for Line Officers.
3. Promotion to commissioned rank of deserving Warrant Officers.
4. Adoption (for all sea-going corps) of Army pay, rank for rank.
5. The establishment of a new grade of Warrant Officers for the mechanical branch of the service.
6. Enlistments to be hereafter four years, instead of three, with provision for retirement of enlisted men after thirty years' service.
7. Reorganization and increase of the Marine Corps.

Owing to the fact that Engineer Officers were appointed under different laws, with different systems of training, it seemed impossible to frame any one general provision which would apply with fairness to the 176 officers comprising the whole corps. It was found necessary, therefore, to cover the details of amalgamation by the following six sections:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the officers constituting the Engineer Corps of the Navy be, and are hereby, transferred to the Line of the Navy, and shall be commissioned accordingly.

SECTION 2. That Engineer Officers holding the relative rank of captain, commander and lieutenant-commander shall take rank in the Line of the Navy, according to the dates at which they attained such relative rank. Engineer Officers graduated from the Naval Academy from 1868 to 1876, both years inclusive, shall take rank in the Line next after officers in the Line who graduated from the Naval Academy in the same year with them: *Provided,* That when the date of a Line Officer's commission as captain, commander or lieutenant-commander and the date when the Engineer Officer attained the same relative rank of captain, commander or lieutenant-commander are the same, the Engineer Officer shall take rank after such Line Officer.

SEC. 3. That Engineer Officers who completed their Naval Academy course of four years from 1878 to 1880, both inclusive, shall take rank in the Line as determined by the Academic Board under the Department's instructions of December 1, 1897, and Engineer Officers who completed their Naval Academy course of four years in 1881 and 1882 shall take rank in the line as determined by the merit roll of graduating classes at the conclusion of the six years' course, June, 1883 and 1884: *Provided,* That those Engineer Officers who were appointed from civil life, and whose status is not fixed by Section 2 of this act, shall take rank with other Line Officers according to the dates of their first commissions, respectively: *And provided, further,* That the Engineer Officers who completed their Naval Academy course of four years in 1881 and 1882 shall retain among themselves the same relative standing as shown on the Navy Register at the date of the passage of this act.

SEC. 4. That Engineer Officers transferred to the Line who are below the rank of commander, and extending down to, but not including, the first engineer who entered the Naval Academy as cadet midshipman, shall perform sea or shore duty, and such duty shall be such as performed by Engineers in the Navy: *Provided,* That any officer described in this section may, upon his own application, made within six months after the passage of this act, be assigned to the general duties of the Line, if he pass the examination now provided by law as preliminary to promotion to the grade he then holds, failure to pass not to displace such officer from the list of officers for sea or shore duty such as is performed by Engineers in the Navy.

SEC. 5. That Engineer Officers transferred to the Line to perform Engineer duty only who rank as, or above, commander, or who subsequently attain such rank, shall perform shore duty only.

SEC. 6. That all Engineer Officers not provided for in Sections 4 and 5 transferred to the Line shall perform the duties now performed by Line Officers of the same grade: *Provided,* That after a period of two years subsequent to the passage of this act they shall be required to pass the examinations now provided by law as preliminary to promotion to the grade they then hold, and subject to existing law governing examinations for promotion.

It will be observed that the transferred Engineer Officers are divided into three groups. The older men, who originally entered the service directly from civil life, all of whom are now above fifty years of age, and who naturally are beyond the time in life when a new profession can be undertaken with success, form the first section. These officers, numbering about twenty-five, are hereafter to be eligible only for engineering duty at Navy Yards and other shore stations. The middle group of seventy officers is composed almost entirely of graduates of the Naval Academy, and they are given the option of qualifying for the general duties of the new Line or of retaining engineering only. The third section, comprising the remainder of the corps, includes only those officers who were appointed as naval cadets and who, for three years in many cases and four years in some, pursued absolutely the same course at the Naval School as the younger Line Officers. All this group—alternation being the cardinal principle involved in amalgamation—are compelled to qualify in navigation, gunnery, etc., and are to be assigned to duty in the engine room and on deck alternately. If the bill is drawn on correct principles it is perfectly reasonable to require the younger officers of the third group to qualify for the general duties, because otherwise it would be to admit that the whole idea of the bill is a false one.

A close study of the intent of the provisions relating to amalgamation show that no violent changes are contemplated. The older Line Officers, who have had but a cursory course in engineering during their academic training at Annapolis, will still perform deck duty; the older Engineers will continue to be assigned to duty in connection with the machinery. For a year or two even the duties of the younger men will be but little altered. Then, as time goes on, the younger officers of the present Line will be required to stand watch in the engine room and the younger officers of the present Engineer Corps will have to familiarize themselves with the duties of Line Officers. In the meantime, in order that the naval officer of the future may be thoroughly qualified for his enlarged duties, it will be necessary to rearrange the course of instruction at the Naval Academy for all naval cadets, making it at least as good in engineering as that formerly taught to the Engineer division, a full description of which appeared in the last issue of this journal.

While, under the new organization, it is quite certain the unfortunate internal strife which has existed for years between former Engineer and Line Officers will be a thing of the past, the practical operation of the bill, so far as it affects the efficiency of the engineering department, will be watched with interest both at home and abroad. Engineers in other navies, and especially in the British service, have long contended for a proper recognition and status of their corps, and the struggle is now going on with ever increasing bitterness. In the United Kingdom, however, the solution suggested differs from that adopted by us, inasmuch as a separate corps of Engineer Officers, with military rank and authority, is advocated; in addition, and for the purpose of maintaining full discipline in the mechanical department, it is considered necessary to vest in the Chief Engineer the right to inflict minor punishment on the subordinate *personnel* of the engine and fire rooms.

Rear Admiral Melville, the present Engineer-in-Chief of the Navy, in a letter recently published, has this to say of the amalgamation features of the bill:

The success of this radical experiment will depend entirely upon the officers in the Navy, and particularly upon those who were in the regular line before the amalgamation took place. If they—the younger ones particularly—will willingly and zealously undertake the work that was previously done by the officers of the Engineer Corps, I believe that this thing will work. If they do not, and if the tendency becomes wholly to absorb the younger Engineers into the Line and to fall back upon the newly created corps of Warranted Machinists for engineering duties, I think it will fail. In that event we shall be the unwilling witnesses of a repetition of history. For as soon as the Warrant Machinists discover that they are being relied upon as Engineers they will most surely advocate for the position that Engineers have in commercial life, in other navies, and, in fact, in all walks of life where mechanisms have influenced human industries.

The following sections fix the maximum numbers in the several grades of the new Line; abolish "relative" rank and the grade of Commodore on the active list; provide for a proper regulated flow of promotion in the Line; limit and reorganize the Corps of Constructors and confer certain privileges upon those officers with a creditable record who served during the Civil War after reaching the age of retirement:

SEC. 7. That the active list of the Line of the Navy, as constituted by Section 1 of this act, shall be composed of 18 rear-admirals, 70 captains, 112 commanders, 170 lieutenant-commanders, 300 lieutenants, and not more than a total of 350 lieutenants (junior grade) and ensigns: *Provided*, That each rear-admiral embraced in the nine lower numbers of that grade shall receive the same pay and allowance as are now allowed a brigadier-general in the Army. Officers, after performing three years' service in the grade of ensign, shall, after passing the examinations now required by law, be eligible to promotion to the grade of lieutenant (junior grade): *Provided*, That when the office of chief of bureau is filled by an officer below the rank of rear-admiral, said officer shall, while holding said office, have the rank of rear-admiral and receive the same pay and allowance as are now allowed a brigadier-general in the Army: *And provided further*, That nothing contained in this section shall be construed to prevent the retirement of officers who now have the rank or relative rank of commodore with the rank and pay of that grade: *And provided further*, That all sections of the Revised Statutes which, in defining the rank of officers or positions in the Navy, contain the words "the relative rank of" are hereby amended so as to read "the rank of," but officers whose rank is so defined shall not be entitled, in virtue of their rank to command in the Line or in other Staff Corps. Neither shall this act be construed as changing the titles of officers in the Staff Corps of the Navy. No appointments shall be made of Civil Engineers in the Navy on the active list under Section 413 of the Revised Statutes in excess of the present number, twenty-one.

SEC. 8. That Officers of the Line in the grades of captain, commander and lieutenant-commander may, by official application to the Secretary of the Navy, have their names placed on a list which shall be known as the list of "Applicants for voluntary retirement," and when at the end of any fiscal year the average vacancies for the fiscal years subsequent to the passage of this act above the grade of commander have been less than thirteen, above the grade of lieutenant-commander less than twenty, above the grade of lieutenant less than twenty-nine, and above the grade of lieutenant (junior grade) less than forty, the President may, in the order of the rank of the applicants, place a sufficient number on the retired list with the rank and three-fourths the sea pay of the next higher grade, as now existing, including the grade of commodore, to cause the aforesaid vacancies for the fiscal year then being considered.

SEC. 9. That should it be found at the end of any fiscal year that the retirements pursuant to the provisions of law now in force, the voluntary retirements provided for in this act, and casualties are not sufficient to cause the average vacancies enumerated in Section 8 of this act, the Secretary of the Navy shall, on or about the 1st day of June, convene a Board of five rear-admirals, and shall place at its disposal the service and medical records on file in the Navy Department of all the officers in the grades of captain, commander, lieutenant-commander and lieutenant. The Board shall then select, as soon as practicable after July 1, a sufficient number of officers from the before mentioned grades, as constituted on June 30 of that year, to cause the average vacancies enumerated in Section 8 of this act. Each member of said Board shall swear, or affirm, that he will, without prejudice or partiality, and having in view solely the special fitness of officers and the efficiency of the naval service, perform the duties imposed upon him by this act. Its finding, which shall be in writing, signed by all the members, not less than four governing, shall be transmitted to the President, who shall thereupon, by order, make the transfers of such officers to the retired list as are selected by the Board: *Provided*, That not more than five captains, four commanders, four lieutenant-commanders and two lieutenants are so retired in any one year. The promotions to fill the vacancies thus created shall date from the 30th day of June of the current year: *And provided further*, That any officer retired under the provisions of this section shall be retired with the rank and three-fourths the sea pay of the next higher grade, including the grade of commodore, which is retained on the retired list for this purpose.

SEC. 10. That of the naval constructors five shall have the rank of captain, five of commander, and all others that of lieutenant-commander or lieutenant. Assistant naval constructors shall have the the rank of lieutenant or lieutenant (junior grade). Asistant naval constructors shall be promoted to the grade of naval constructor after not less than eight or more than fourteen years' service as assistant naval constructor: *Provided*, That the whole number of naval constructors and assistant naval constructors on the active list shall not exceed forty in all.

SEC. 11. That any officer of the Navy, with a creditable record, who served during the Cival War, shall, when retired, be retired with the rank and three-fourths the sea pay of the next higher grade.

Previous to the passage of the bill the active list of the Line and Engineer Corps, in all grades, was limited by law to 726 and 196 officers respectively, or, in all 922. An increase to 1,020 is provided for in the new organization to meet the requirements of an increased matériel. Any future enlargement of the *personnel*, should it be necessary by reason of the seemingly sound policy of adding ships year by year to the Navy, can readily be adjusted by a percentage increase of the numbers established for each grade by the bill. This course is advocated by Rear Admiral Crowninshield, Chief of the Bureau of Navigation, in his annual report for 1898, who states that these numbers received the very careful consideration of the Board, and were fixed according to the needs of the service at the time the bill was framed, in 1897.

The clause granting actual instead of relative rank to Staff Officers will unquestionably remove a source of discontent which has been a serious menace to the efficiency of the Navy. While authority is expressly denied to command outside of the corps to which a

Staff Officer belongs, he is nevertheless empowered to exercise military prerogatives, under certain circumstances, in his own corps. This follows very closely the custom of the Army, which has always given entire satisfaction.

In abolishing the grade of Commodore, except for retirement purposes, the universal custom of the rest of the world is followed in making the lowest flag rank that of Rear Admiral.

Sections 8 and 9, which aim to cause an even flow of promotion during an officer's active career, are of vital importance to the efficiency of the Navy. Heretofore this matter has been left entirely to chance, the United States being the only service worthy of the name in which such a faulty system prevailed. In consequence of this, there have been in the past periods of congestion and stagnation, followed by rapid advancement, with a regular recurrence of these conditions. Foreign navies long ago recognized the evils of a system based purely on seniority promotion, and various expedients are in vogue to correct this defect. All, however, reach the same end by slightly different methods.

Provision for the commissioning of Warrant Officers is contained in the following section:

SEC. 12. That boatswains, gunners, carpenters and sailmakers shall after ten years from date of warrant be commissioned chief boatswains, chief gunners, chief carpenters and chief sailmakers, to rank with but after ensign: *Provided*, That the chief boatswains, chief gunners, chief carpenters and chief sailmakers shall on promotion have the same pay and allowances as are now allowed a second lieutenant in the Marine Corps: *Provided*, That the pay of boatswains, gunners, carpenters and sailmakers shall be the same as that now allowed by law: *Provided further*, That nothing in this act shall give additioal rights to quarters on board ship or to command, and that immediately after the passage of this act boatswains, gunners, carpenters and sailmakers, who have served in the Navy as such for fifteen years, shall be commissioned in accordance with the provisions of this section, and thereafter no Warrant Officer shall be promoted until he shall have passed an examination before a Board of chief boatswains, chief gunners, chief carpenters and chief sailmakers, in accordance with regulations prescribed by the Secretary of the Navy.

Warrant Officers are now invariably recruited from the enlisted force, being subjected to a rigid mental and physical examination previous to appointment. This provision allows advancement to the grade of ensign, and is the only means by which an enlisted man can gain a commission.

The bill makes a radical change in the compensation allowed the sea-going corps:

SEC. 13. That, after June 30, 1899, commissioned Officers of the Line of the Navy and of the Medical and Pay Corps shall receive the same pay and allowances, except forage, as are or may be provided by or in pursuance of law for the officers of corresponding rank in the Army: *Provided*, That such officers when on shore shall receive the allowances, but fifteen per cent less pay than when on sea duty; but this provision shall not apply to Warrant Officers commissioned under Section 12 of this act: *Provided further*, That when naval officers are detailed for shore duty beyond seas they shall receive the same pay and allowances as are or may be provided by or in pursuance of law for officers of the Army detailed for duty in similar places: *Provided further*, That naval chaplains, who do not possess relative rank, shall have the rank of lieutenant in the Navy; and that all officers, including Warrant Officers, who have been or may be appointed to the Navy from civil life shall, on the date of appointment, be credited, for computing their pay, with five years' service. And all provisions of law authorizing the distribution among captors of the whole or any portion of the proceeds of vessels, or any property hereafter captured, condemned as prize, or providing for the payment of bounty for the sinking or destruction of vessels of the enemy hereafter occurring in time of war, are hereby repealed: *And provided further*, That no provision of this act shall operate to reduce the present pay of any commissioned officer now in the Navy; and in any case in which the pay of such an officer would otherwise be reduced he shall continue to receive pay according to existing law: *And provided further*, That nothing in this act shall operate to increase or reduce the pay of any officer now on the retired list of the Navy.

The present Pay Table of the Navy was framed in 1871, and while, no doubt, it was fair and equitable for the conditions which then existed, so great has been the change in late years that it now presents many incongruities. It seems plain that the Table was not founded on any rational plan, as each of the different corps received pay on quite a different basis. As an easy solution of an intricate problem, the comprehensive Army Pay Table is substituted, which takes into account not only the rank held by an officer, but in addition, the number of years of active service.

In order to increase the efficiency of the skilled mechanics and offer some reward for faithfulness and zeal, a new Warrant grade is created—that of Warrant Machinist. It is believed the inducement thus held out will cause the most capable of the mechanical force to remain in the service, which at present is not the case. The pay of Warrant Machinists is $1,200 per annum at entry, increasing gradually, with length of service, up to $1,800, after twelve years from date of appointment.

SEC. 14. That upon the passage of this act the Secretary of the Navy shall appoint a Board for the examination of men for the position of Warrant Machinists, 100 of whom are hereby authorized. The said examination shall be open, first, to all machinists by trade, of good record in the naval service, and if a sufficient number of machinists from the Navy are not found duly qualified, then any machinist of good character, not above thirty years of age, in civil life shall be eligible for such examination and appointment to fill the remaining vacancies. All subsequent vacancies in the list of Warrant Machinists shall be filled by competitive examination before a Board ordered by the Secretary of the Navy, and open to all machinists by trade who are in the Navy, and machinists of good character, not above thirty years of age, in civil life authorized by the Secretary of the Navy to appear before said Board, and, where candidates from civil life and from the naval service possess equal qualifications, the preference shall be given to those from the naval service.

SEC. 15. That the pay of Warrant Machinists shall be the same as that of Warrant Officers, and they shall be retired under the provisions of existing law for Warrant Officers. Warrant Machinists shall receive at first an acting appointment, which may be made permanent under regulations established by the Navy Department for other Warrant Officers. They shall take rank with other Warrant Officers according to date of appointment and shall wear such uniform as may be prescribed by the Navy Department.

The succeeding two sections provide for an enlistment period of four years and establish a retired list for deserving enlisted men:

SEC. 16. That hereafter the term of enlistment of all enlisted men of the Navy shall be four years: *Provided*, That Section 1573, Revised Statutes, be amended to read: "If any enlisted man or apprentice, being honorably discharged, shall re-enlist for four years within four months thereafter, he shall, on presenting his honorable discharge or on accounting in a satisfactory manner for its loss, be entitled to pay during the said four months equal to that to which he would have been entitled if he had been employed in actual service; and that any man who has received an honorable discharge from his last term of enlistment, or who has received a recommendation for re-enlistment upon the expiration of his last term of service of not less than three years, who re-enlists for a term of four years within four months from the date of his discharge, shall receive an increase of one dollar and thirty-six cents per month to the pay prescribed for the rating in which he serves for each consecutive re-enlistment."

SEC. 17. That when an enlisted man or appointed petty officer has served as such thirty years in the United States Navy, either as an enlisted man or petty officer, or both, he shall, by making application to the President, be placed on the retired list hereby created, with the rank held by him at the date of retirement; and he shall thereafter receive 75 per centum of the pay and allowances of the rank or rating upon which he was retired: *Provided*, That if said enlisted man or appointed petty officer had active service in the Navy or in the Army or Marine Corps, either as volunteer or regular, during the Civil or Spanish-American war, such war service shall be computed as double time in computing the thirty years necessary to entitle him to be retired: *And provided further*, That applicants for retirement under this section shall, unless physically disqualified for service, be at least fifty years of age.

A radical reorganization of the Marine Corps is covered in the remaining sections of the bill. The enlisted strength of the corps is increased from 3,073 to 6,000, with a corresponding increase in the officers:

SEC. 18. That from and after the date of the approval of this act the active list of the Line Officers of the United States Marine Corps shall consist of one brigadier-general commandant, five colonels, five lieutenant colonels, ten majors, sixty captains, sixty first lietenants and sixty second lieutenants: *Provided*, That vacancies in all grades in the Line created by this section shall be filled as far as possible by promotion by seniority from the Line Officers on the active list of said corps: *And provided further*, That the commissions of officers now in the Marine Corps shall not be vacated by this act: *And provided further*, That vacancies in the grade of brigadier-general shall be filled by selection from officers on the active list of the Marine Corps not below the grade of field officer.

SEC. 19. That the vacancies existing in said corps after the promotions and appointments herein provided for shall be filled by the President from time to time, whenever the actual needs of the naval service require it, first from the graduates of the Naval Academy in the manner now provided by law; or second, from those who are serving or who have served as second lieutenants in the Marine Corps during the war with Spain; or, third, from meritorious non-commissioned officers of the Marine Corps; or, fourth, from civil life: *Provided*, That after said vacancies are once filled there shall be no further appointments from civil life.

SEC. 20. That no person except such officers or former graduates of the Naval Academy as have served in the war with Spain, as hereinbefore provided for, shall be appointed a commissioned officer in the Marine Corps who is under twenty or over thirty years of age; and that no person shall be appointed a commissioned officer in said corps until he shall have passed such examination as may be prescribed by the President of the United States, except graduates of the Naval Academy, as above provided. That the officers of the Marine Corps above the grade of captain, except brigadier-general, shall, before being promoted, be subject to such physical, mental and moral examination as is now, or may hereafter be, prescribed by law for other officers of the Marine Corps.

SEC. 21. That upon the passage of this act not more than forty-five of the captains, forty-five first lieutenants and forty-five second lieutenants herein provided for shall be appointed: fifteen captains, fifteen first lieutenants and fifteen scond lieutenants to be appointed subsequently to January 1, 1900.

SEC. 22. That the staff of the Marine Corps shall consist of one adjutant and inspector, one quartermaster and one paymaster, each with the rank of colonel; one assistant adjutant and inspector, two assistant quartermasters and one assistant paymaster, each with the rank of major; and three asistant quartermasters, with the rank of captain. That the vacancies created by this act in the departments of the adjutant and inspector and paymaster shall be filled first by promotion, according to seniority of the officers in each of these departments, respectively, and then by selection from the Line Officrs on the active list of the Marine Corps not below the grade of captain, and who shall have seen not less than ten years' service in the Marine Corps. That the vacancies created by this act in the quartermaster's department of said corps shall be filled, first by promotion according to seniority of the officers in this Department, and then by selection from the Line Officers on the active list of said corps not below the grade of first lieutenant: *Provided*, That all vacancies hereafter occurring in the staff of the Marine Corps shall be filled first by promotion, according to seniority of the officers in their respective departments, and then by selection from Officers of the Line on the active list, as hereinbefore provided for.

SEC. 23. That the enlisted force of the Marine Corps shall consist of 5 sergeant majors, 1 drum major, 20 quartermaster sergeants, 72 gunnery sergeants, with the rank and allowance of the first sergeant, and whose pay shall be thirty-five dollars per month; 60 first sergeants; 240 sergeants; 480 corporals; 80 drummers; 80 trumpeters, and 4,962 privates.

SEC. 24. That the band of the United States Marine Corps shall consist of one leader, with the pay and allowances of a first lieutenant; one second leader, whose pay shall be seventy-five dollars per month, and who shall have the allowances of a sergeant major; thirty first-class musicians, whose pay shall be sixty dollars per month; and thirty second-class musicians, whose pay shall be fifty dollars per month and the allowances of a sergeant; such musicians of the band to have no increased pay for length of service.

SEC. 25. That the oath of allegiance now provided for the officers and men of the Army and Marine Corps shall be administered hereafter to the officers and men of the Navy.

The bill concludes with the usual clause that all acts and parts of acts, in so far as they conflict with the provisions of the present act, are repealed.

AMENDMENTS TO THE U. S. STEAMBOAT RULES AND REGULATIONS FOR 1899.

At the recent meeting of the Board of Supervising Inspectors, held in Washington, D. C., with Supervising Inspector General James A. Dumont in the chair, amendments were made to the existing steamboat rules and regulations. Following is the text of the rules amended in part only, the parts stricken out being inclosed in brackets [thus], while the additions to such paragraphs are printed in *italics*. Entirely new sections and paragraphs of sections are set in plain type, preceded by the word (new) in parentheses.

RULES.

Rule I.

SECTION 4. (New paragraph at end of section.)

The diameter of rivets, rivet holes, distance between centers of rivets and distance from centers of rivets to edge of lap for different thicknesses of plates for single and double riveting shall be determined by the rules of the British Board of Trade. This rule shall take effect on July 1, 1899. (See Appendix.)

Rule II.

SECTION 2. (Second paragraph.)

All boilers built for marine purposes [after July 1, 1898,] shall be required to have [all] *the rivet holes in the shell, heads, steam and mud drums, and all other parts of the boiler, (excepting for longitudinal and circumferential seams in flues for same 20 inches outside diameter and under)*, fairly drilled instead of punched. [: and, the longitudinal laps of their cylindrical parts double-riveted, to be entitled to 20 per cent additional pressure.]

Boilers, to be entitled to the 20 per cent additional pressure allowed by law, must have the longitudinal laps of their cylindrical parts double-riveted.

SECTION 14. (New, to precede first paragraph.)

14. Corrugated furnace flues constructed with corrugations eight inches from center to center, the radius of outer corrugation being not more than one-half of the reverse or suspension curve, the plain parts at the ends not exceeding nine inches in length, made of plates not less than five-sixteenths of an inch thick, when new, corrugated with practically true circles, shall be allowed a steam pressure in accordance with the following formula:

$$\text{Pressure in pounds} = \frac{15000}{D} \times T,$$

where T = thickness, in inches;
D = mean diameter, in inches.

EXAMPLE.

Given a corrugated flue as above, 40 inches in diameter, $\frac{5}{16}$ inch thick; required, the pressure of steam allowable.

$$\frac{15000}{40} \times \frac{5}{16} = 117.18 \text{ pounds.}$$

(First paragraph, first line.)

The strength of all corrugated flues, *other than described in the preceding paragraph of this section,* * * * .

SECTION 15. (First two paragraphs amended and transposed from page 30 to follow the examples on page 33, Rules and Regulations.)

15. The steam pressure allowable and the thickness of material required for flues used as furnaces in *vertical* boilers, [and for vertical boiler] *such* furnace [s] *flues* having a diameter of not more than 42 inches and a [height] *length* of not more than 40 inches, except as hereafter otherwise provided, shall be determined by the following formula, viz.:

$$P = \frac{89600 \times T^2}{L \times D},$$

where P = pressure of steam allowable, in pounds;
T = thickness of flue, in decimals of an inch;
L = length of flue, in feet [not to exceed 8 feet];
D = diameter of flue, in inches.

EXAMPLE.

(New, in lieu of old.)

Given a vertical furnace flue $3\frac{1}{3}$ feet in length, 42 inches in diameter, and .5 inch thick; required, the pressure allowable by the inspectors.

Substituting the values in the formula, and performing the operation indicated, the pressure allowable,

$$P = \frac{89600 \times .25}{3\frac{1}{3} \times 42} = 160 \text{ pounds.}$$

SECTION 15. (Third paragraph.)

[Provided, That when such] *When plain horizontal* flues are made in sections * * * the distance between the flanges, or the distance between such angle-iron rings, shall be taken as the length of the flue in determining the pressure allowable, *which pressure shall be determined in accordance with the following formula:*

$$P = \frac{89600 \times T^2}{L \times D},$$

where P = pressure of steam allowable, in pounds;
T = thickness of flue, in decimals of an inch;
L = length of section, in feet;
D = diameter of flue, in inches.

SECTION 15. (New, added to section.)

Formula for crown bars over back connection and furnaces.

$$\text{Working pressure} = \frac{C \times d^2 \times T}{(W - P) \times D \times L},$$

where W = width of combustion box, in inches;
P = pitch of supporting bolts, in inches;
D = distance between girders from center to center, in inches;
L = length of girder, in feet;
d = depth of girder, in inches;
T = thickness of girder, in inches;
C = 550 when the girder is fitted with one supporting bolt;
C = 825 when the girder is fitted with two or three supporting bolts;
C = 935 when the girder is fitted with four supporting bolts.

EXAMPLE.

Given W = 34 inches, P = 7.5 inches, D = 7.75 inches, L = 2.927 feet, d = 7.5 inches, T = 2 inches, C = 825, then, substituting in formula,

$$\text{Working pressure} = \frac{825 \times 7.5^2 \times 2}{(34 - 7.5) \times 7.75 \times 2.927} =$$

154.3 pounds.

SECTION 21. (Second paragraph.)

All manholes for the shell of boilers over 40 inches in diameter, *where practicable for use*, shall have an opening not less than 11 by 15 inches in the clear, except * * * .

SECTION 38. (Second paragraph, page 41.)

The terminal and intermediate joints of all wrought-iron and homogeneous steel feed and steam pipes over [2] *3* inches in diameter [and not over 5 inches in diameter], other than on pipe or coil boilers or steam generators, shall be made of wrought iron, homogeneous steel or [malleable iron] flanges [or] *of* equivalent material; * * * .

SECTION 38. (Third paragraph, page 41.)

But where such pipes are made of extra heavy lap-welded steam pipe, *up to and including 5 inches*, the flanges may be attached with screw threads; and all joints in bends may be made with good and substantial malleable-iron elbows or equivalent material.

SECTION 38. (Last paragraph, page 41.)

All lap-welded iron or steel steam pipes over 5 inches in diameter or riveted wrought-iron or steel steam pipes over 5 inches in diameter, in addition to being expanded into tapered holes, and substantially beaded into recess in face of flanges [as provided in preceding paragraph for steam and feed pipes exceeding 2 inches and not exceeding 5 inches in diameter], shall be substantially and firmly riveted with good and substantial rivets through the hubs of such flanges; and no such hubs shall project from such flanges less than 2 inches in any case.

SECTION 38. (Second paragraph, page 42.)

When holes exceeding 6 inches in diameter are cut in boilers for pipe connections, man and hand hole plates, such holes shall be reinforced, either on the inside or outside of boiler, with reinforcing plates, which shall be securely riveted to the boiler, *in flat surfaces; and, where such opening is made in the circumferential plates of such boilers, the reinforcing ring shall have a sectional area of at least one-half the area of material there would be in a line drawn across such opening parallel with the longitudinal seams of such portion of the boiler;* * * * .

SECTION 40. (New.)

40. No cast-iron nozzles, branch pipes, or elbows shall be used in connecting steam drums, superheaters, branch pipes, or steam pipes to boilers, and no cast-iron flanges will be allowed to be used on boilers for marine purposes unless such cast iron has been officially tested and test on record in the office of the local inspectors where boiler with such appliances was constructed, and no cast iron with a tensile strength of less than 30,000 pounds will be permitted to be used for such purposes.

Rule V.

SECTION 1. (First paragraph, proviso struck out.)

[Provided, however, That the applicant for renewal is at the time personally within the jurisdiction of the United States inspection laws, as defined in sections 4400 and 4447 of the Revised Statutes.]

(New paragraph inserted after 15th line.)

All licenses hereafter issued to masters, mates, pilots, and engineers shall be filled out on the face with pen and black ink instead of typewritten.

(Transposed from section 10, and added to fourth paragraph.)

[Provided, however,] *; and*, before granting or renewing a license to pilots, masters, or engineers, inspectors shall satisfy themselves that they can properly hear the bell and whistle signals.

SECTION 7.

7. Second-class pilots may be allowed to take charge of steamers not exceeding 100 tons burden, may be authorized by the license granted to act in charge of a watch as assistant to a first-class pilot on *passenger*, freight, and towing steamers of all tonnage.

(Paragraph transposed from section 11, Rule V.)

On the Northwestern Lakes and connecting waters, any person holding a second-class pilot license may come before any local board for examination for first-class pilot license after having served one year as wheelsman, watchman, or as assistant to a first-class pilot on freight, towing, or passenger steamers, such service to have been within two years preceding the application for raise of grade.

SECTION 10. (First paragraph, new.)

10. No original license as master or mate of ocean or coastwise steamers, pilot of steam vessels, or as master or chief mate of sail vessels shall be granted, except on the official certificate of a surgeon of the Marine Hospital Service that the applicant is free from the defect known as color blindness. No renewal of license shall be granted to any officer of the classes named who has not been previously examined and passed for color blindness.

SECTION 10. (Second paragraph, amendment of old third paragraph.)

[In case of original or renewal of any license of any master or pilot who has not been examined] *Any person requring examination* for color blindness, [and] who is living at a distance of 100 miles or more from a surgeon of the Marine Hospital Service, [he] may be examined for color blindness by any respectable physician residing in the same town or locality with said applicant; * * * .

(Old second paragraph transposed to third, and fourth paragraph amended as indicated in section 1, Rule V, herein, by transposition of proviso.)

SECTION 14. (Fourth paragraph, as follows, struck out. See section 10, Rule V, herein.)

[And that hereafter no original master or chief mate of ocean or coastwise steamers shall be granted a license without first having been examined and passed for color blindness.]

SECTION 15.

15. * * * And it shall be the duty of such master, or of the mate or officer next in command, once at least in each week, to call all hands to quarters and exercise them in the discipline, *and in the unlashing and swinging out of the lifeboats, weather permitting, and in the* use of the fire pumps and all other apparatus for the safety of life on board of such vessel, * * * .

SECTION 26. (New.)

Local inspectors may, upon due application, license as masters and chief mates of sail vessels of over 700 tons, upon receipt of satisfactory documentary evidence, to be filed in their office, that said masters or mates have been actually employed as such officers on vessels of the tonnage named, for the full period of twelve months preceding the application for license, provided such officers shall be found upon examination to be free from color blindness.

Applicants for master's or mate's license on sail vessels, who have had no previous service as either master or mate, except on rivers and on the Great Lakes, must be duly examined in navigation the same as required for masters and mates of steam vessels, such examinations to be in writing; and the applicants must be free from color blindness:

Provided, That no master, except as provided in the first paragraph of this section, shall be licensed who has not served a full term of one year on such sail vessels as chief mate, nor shall any person be eligible to be examined as chief mate of sail vessel, unless he can furnish satisfactory documentary evidence that he had at least three full years' experience on sail vessels of three hundred gross tons and upward.

Rule IX.

SECTION 8. (Third paragraph.)

All steam whistles shall be placed not less than 6 feet above the top of the pilot house of steam vessels where the height of smokestack will admit the attachment of same below its top, when not hinged for passing under bridges, *except upon steamers navigating the Red River of the North and rivers whose waters flow into the Gulf of Mexico, and steamers of less than* *one hundred gross tons, whose steam whistles shall be placed not less than two feet above the tops of their pilot houses;* and it shall be the duty of inspectors to enforce this rule at the annual inspection.

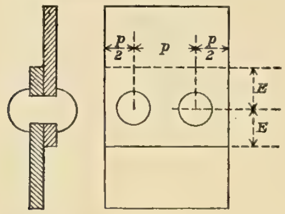
Rule X.

SECTION 8. (Repealed.)

[8. All steam vessels (except upon the Red River of the North and rivers whose waters flow into the Gulf

IRON PLATES AND IRON RIVETS

SINGLE-RIVETED LAP JOINTS.



Thickness of plates.	Diameter of rivets.	Pitch of rivets.	Center of rivets to edge of plates.
T	d	p	E
1/4	5/8	1.524	.937
9/32	21/32	1.600	.984
5/16	11/16	1.676	1.031
11/32	23/32	1.753	1.078
3/8	3/4	1.829	1.125
13/32	25/32	1.905	1.171
7/16	13/16	1.981	1.218
15/32	27/32	2.036	1.265
1/2	7/8	2.077	1.312
17/32	29/32	2.120	1.359
9/16	15/16	2.164	1.406
19/32	31/32	2.210	1.453
5/8	1	2.256	1.500
21/32	1 1/32	2.304	1.546
11/16	1 1/16	2.352	1.593
23/32	1 3/32	2.400	1.640
3/4	1 1/8	2.450	1.687
25/32	1 5/32	2.500	1.734
13/16	1 3/16	2.550	1.781
27/32	1 7/32	2.601	1.828
7/8	1 1/4	2.652	1.875
29/32	1 9/32	2.703	1.921
15/16	1 5/16	2.755	1.968

of Mexico), when engaged in towing during fog or thick weather, shall sound three distinct blasts of their steam whistles in quick succession, repeating at intervals not exceeding one minute.]

Rules of Practice.

SECTION 6.

At any time before the conclusion of the evidence the charge or charges, *if being tried on charges,* may be amended, notice of said amendment being furnished to the accused of the nature of such amendment, but no amendment shall be permitted after the conclusion of the evidence.

Pilot Rules, Atlantic and Pacific Coast Inland Waters.

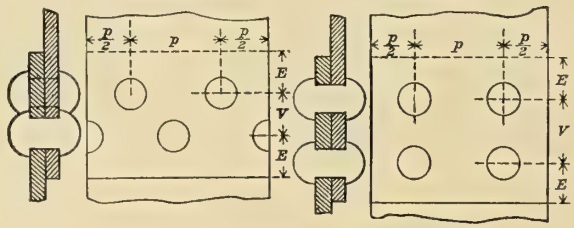
RULE III [(Act of June 7, 1897)]. If, when steam vessels are approaching each other, either vessel fails to understand the course or intention of the other, from any cause, the vessel so in doubt shall immediately signify the same by giving several short and rapid blasts, not less than four, of the steam whistle; *and, if the vessels shall have approached within half a mile of each other, both shall be immediately slowed to a speed barely sufficient for steerageway until the proper signals are given, answered and understood, or until the vessels shall have passed each other.*

Vessels approaching each other from opposite directions are forbidden to use what has become technically known among pilots as "cross signals"—that is, answering one whistle with two, and answering two whistles with one. In all cases, and under all circumstances, a pilot receiving either of the whistle signals provided in the rules, which for any reason he deems injudicious to comply with, instead of answer-

IRON PLATES AND IRON RIVETS.

DOUBLE-RIVETED LAP JOINTS.

ZIGZAG RIVETING. CHAIN RIVETING.



Thickness of plates.	Diameter of rivets.	Pitch of rivets.	Center of rivets to edge of plates.	Distance between rows of rivets.	
				Zigzag riveting.	Chain riveting.
T	d	p	E	V	V
5/16	5/8	2.272	.937	1.145	1.750
11/32	21/32	2.386	.984	1.202	1.812
3/8	11/16	2.500	1.031	1.260	1.875
13/32	23/32	2.613	1.078	1.317	1.937
7/16	3/4	2.727	1.125	1.374	2.000
15/32	25/32	2.826	1.171	1.426	2.062
1/2	13/16	2.886	1.218	1.465	2.125
17/32	27/32	2.948	1.265	1.504	2.187
9/16	7/8	3.013	1.312	1.544	2.250
19/32	29/32	3.079	1.359	1.585	2.312
5/8	15/16	3.146	1.406	1.626	2.375
21/32	31/32	3.215	1.453	1.667	2.437
11/16	1	3.284	1.500	1.709	2.500
23/32	1 1/32	3.355	1.546	1.751	2.562
3/4	1 1/16	3.426	1.593	1.794	2.625
25/32	1 3/32	3.498	1.640	1.836	2.687
13/16	1 1/8	3.571	1.687	1.879	2.750
27/32	1 5/32	3.645	1.734	1.923	2.812
7/8	1 3/16	3.718	1.781	1.966	2.875
29/32	1 7/32	3.793	1.828	2.009	2.937
15/16	1 1/4	3.867	1.875	2.053	3.000
31/32	1 9/32	3.942	1.921	2.096	3.062
1	1 5/16	4.018	1.968	2.140	3.125

ing it with a cross signal, must at once observe the provisions of this rule.

Lights for Boom Rafts.

(Amendment to resolution of Board of Supervising Inspectors, contained in Pilot Rules for Western Rivers, page 10, Form 2103¼; and page 15, Form 2102½.)

Resolved, * * * Boom rafts with cross binders towed ahead of steamers on the Mississippi and Ohio Rivers, and other waters flowing into the Gulf of Mexico, and on the Red River of the North, shall carry a white light [twelve] *four* feet high at the forward end of the raft, and one such light at each side midway between the forward and after end. * * *

APPENDIX.

The following formulas, equivalent to those of the

British Board of Trade, are given for the determination of the pitch, distance between rows of rivets, diagonal pitch, maximum pitch, and distance from centers of rivets to edge of lap of single and double riveted lap joints, for both iron and steel boilers:

Let p = greatest pitch of rivets, in inches;
n = number of rivets, in one pitch;
p_d = diagonal pitch, in inches;
d = diameter of rivets, in inches;
T = thickness of plate, in inches;
V = distance between rows of rivets, in inches;
E = distance from edge of plate to center of rivet, in inches.

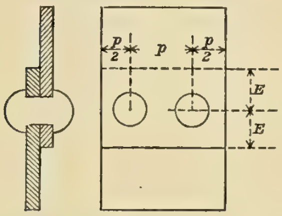
TO DETERMINE THE PITCH.

Iron plates and iron rivets:

$$p = \frac{d^2 \times .7854 \times n}{T} + d.$$

STEEL PLATES AND STEEL RIVETS.

SINGLE-RIVETED LAP JOINTS.



Thickness of plates.	Diameter of rivets.	Pitch of rivets.	Center of rivets to edge of plates.
T	d	p	E
$\frac{1}{4}$	$\frac{11}{16}$	1.562	1.031
$\frac{9}{32}$	$\frac{23}{32}$	1.633	1.078
$\frac{5}{16}$	$\frac{3}{4}$	1.704	1.125
$\frac{11}{32}$	$\frac{25}{32}$	1.775	1.171
$\frac{3}{8}$	$\frac{13}{16}$	1.846	1.218
$\frac{13}{32}$	$\frac{27}{32}$	1.917	1.265
$\frac{7}{16}$	$\frac{7}{8}$	1.988	1.312
$\frac{15}{32}$	$\frac{29}{32}$	2.036	1.359
$\frac{1}{2}$	$\frac{15}{16}$	2.071	1.406
$\frac{17}{32}$	$\frac{31}{32}$	2.108	1.453
$\frac{9}{16}$	1	2.146	1.500
$\frac{19}{32}$	$1\frac{1}{32}$	2.186	1.546
$\frac{5}{8}$	$1\frac{1}{16}$	2.227	1.593
$\frac{21}{32}$	$1\frac{3}{32}$	2.269	1.640
$\frac{11}{16}$	$1\frac{1}{8}$	2.312	1.687
$\frac{23}{32}$	$1\frac{5}{32}$	2.356	1.734
$\frac{3}{4}$	$1\frac{3}{16}$	2.400	1.781
$\frac{25}{32}$	$1\frac{7}{32}$	2.445	1.828
$\frac{13}{16}$	$1\frac{1}{4}$	2.500	1.875
$\frac{27}{32}$	$1\frac{9}{32}$	2.562	1.921
$\frac{7}{8}$	$1\frac{5}{16}$	2.625	1.968
$\frac{29}{32}$	$1\frac{11}{32}$	2.687	2.015
$\frac{15}{16}$	$1\frac{3}{8}$	2.750	2.062

Example: First, for single-riveted joint—

Given, thickness of plate (T) = ½ inch, diameter of rivet (d) = ⅞ inch. In this case, $n = 1$. Required, the pitch.

Substituting in formula, and performing operation indicated,

$$\text{Pitch} = \frac{(\frac{7}{8})^2 \times .7854 \times 1}{\frac{1}{2}} + \frac{7}{8} = 2.077 \text{ inches.}$$

For double-riveted joint—

Given, $t = \frac{1}{2}$ inch, and $d = \frac{13}{16}$ inch. In this case, $n = 2$. Then—

$$\text{Pitch} = \frac{(\frac{13}{16})^2 \times .7854 \times 2}{\frac{1}{2}} + \frac{13}{16} = 2.886 \text{ inches.}$$

For *steel* plates and steel rivets:

$$p = \frac{23 \times d^2 \times n}{28 \times T} + d.$$

Example, for single-riveted joint: Given, thickness of plate = $\frac{1}{2}$ inch, diameter of rivet = $\frac{15}{16}$ inch. In this case, $n = 1$.

$$\text{Pitch} = \frac{23 \times (\frac{15}{16})^2 \times .7854 \times 1}{28 \times \frac{1}{2}} + \frac{15}{16} = 2.071 \text{ inches.}$$

Example, for double-riveted joint: Given, thickness of plate = ½ inch, diameter of rivet = ⅞ inch. $n = 2$. Then—

$$\text{Pitch} = \frac{23 \times (\frac{7}{8})^2 \times .7854 \times 2}{28 \times \frac{1}{2}} + \frac{7}{8} = 2.85 \text{ inches.}$$

FOR DISTANCE FROM CENTER OF RIVET TO EDGE OF LAP.

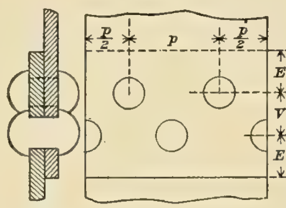
$$E = \frac{3 \times d}{2}.$$

Example: Given, diameter of rivet (d) = ⅞ inch; required, the distance from center of rivet to edge of plate.

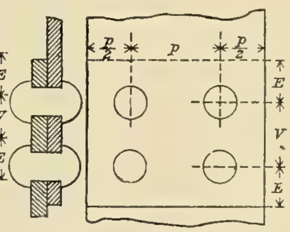
STEEL PLATES AND STEEL RIVETS.

DOUBLE-RIVETED LAP JOINTS.

ZIGZAG RIVETING.



CHAIN RIVETING.



Thickness of plates.	Diameter of rivets.	Pitch of rivets.	Center of rivets to edge of plates.	Distance between rows of rivets.	
				Zigzag riveting.	Chain riveting.
T	d	p	E	V	V
$\frac{5}{16}$	$\frac{11}{16}$	2.291	1.031	1.187	1.875
$\frac{11}{32}$	$\frac{23}{32}$	2.395	1.078	1.240	1.937
$\frac{3}{8}$	$\frac{3}{4}$	2.500	1.125	1.295	2.000
$\frac{13}{32}$	$\frac{25}{32}$	2.604	1.171	1.349	2.062
$\frac{7}{16}$	$\frac{13}{16}$	2.708	1.218	1.403	2.125
$\frac{15}{32}$	$\frac{27}{32}$	2.803	1.265	1.453	2.187
$\frac{1}{2}$	$\frac{7}{8}$	2.850	1.312	1.487	2.250
$\frac{17}{32}$	$\frac{29}{32}$	2.900	1.359	1.522	2.312
$\frac{9}{16}$	$\frac{15}{16}$	2.953	1.406	1.558	2.375
$\frac{19}{32}$	$\frac{31}{32}$	3.008	1.453	1.595	2.437
$\frac{5}{8}$	1	3.064	1.500	1.631	2.500
$\frac{21}{32}$	$1\frac{1}{32}$	3.122	1.546	1.669	2.562
$\frac{11}{16}$	$1\frac{1}{16}$	3.181	1.593	1.707	2.625
$\frac{23}{32}$	$1\frac{3}{32}$	3.241	1.640	1.745	2.687
$\frac{3}{4}$	$1\frac{1}{8}$	3.302	1.687	1.784	2.750
$\frac{25}{32}$	$1\frac{5}{32}$	3.364	1.734	1.823	2.812
$\frac{13}{16}$	$1\frac{3}{16}$	3.427	1.781	1.863	2.875
$\frac{27}{32}$	$1\frac{7}{32}$	3.490	1.828	1.902	2.937
$\frac{7}{8}$	$1\frac{1}{4}$	3.554	1.875	1.942	3.000
$\frac{29}{32}$	$1\frac{9}{32}$	3.618	1.921	1.981	3.062
$\frac{15}{16}$	$1\frac{5}{16}$	3.683	1.968	2.021	3.125
$\frac{31}{32}$	$1\frac{11}{32}$	3.748	2.015	2.061	3.187
1	$1\frac{3}{8}$	3.814	2.062	2.102	3.250

$$E = \frac{3 \times \frac{7}{8}}{2} = 1.312 \text{ inches,}$$

for single or double riveted lap joint.

FOR DISTANCE BETWEEN ROWS OF RIVETS.

The distance between lines of centers of rows of rivets for double, chain-riveted joints (V) should not be less than twice the diameter of rivet, but it is more desirable that V should not be less than $\frac{4d+1}{2}$.

Example under latter formula: Given, diameter of rivet = ⅞ inch, then—

$$V = \frac{(4 \times \frac{7}{8}) + 1}{2} = 2.25 \text{ inches.}$$

For ordinary, double, zigzag-riveted joints,

$$V = \frac{\sqrt{(11p + 4d)\ (p + 4d)}}{10}.$$

Example: Given, pitch = 2.85 inches, and diameter of rivet = ⅞ inch, then—

$$V = \frac{\sqrt{(11 \times 2.85 + 4 \times \frac{7}{8})\ (2.85 + 4 \times \frac{7}{8})}}{10} = 1.487 \text{ inches.}$$

DIAGONAL PITCH.

For double, zigzag-riveted lap joint. Iron and steel.

$$p_d = \frac{6p + 4d}{10}.$$

Example: Given, pitch = 2.85 inches, and d = ⅞ inch, then—

$$p_d = \frac{(6 \times 2.85) + (4 \times \frac{7}{8})}{10} = 2.06 \text{ inches.}$$

MAXIMUM PITCHES FOR RIVETED LAP JOINTS.

For single-riveted lap joints, maximum pitch = $(1.31 \times T) + 1\frac{5}{8}$.

For double-riveted lap joints, maximum pitch = $(2.62 \times T) + 1\frac{5}{8}$.

Example: Given a thickness of plate = ½ inch, required, the maximum pitch allowable.

For single-riveted lap joint, maximum pitch = $(1.31 \times \frac{1}{2}) + 1\frac{5}{8}$ = 2.28 inches.

For double-riveted lap joint, maximum pitch = $(2.62 \times \frac{1}{2}) + 1\frac{5}{8}$ = 2.955 inches.

The tables (pages 30 and 31) taken from the handbook of Thomas W. Traill, entitled "Boilers, Marine and Land, Their Construction and Strength," may be taken for use in single and double riveted joints as approximating the formulas of the British Board of Trade for such joints.

British steel makers and shipbuilders must feel dissatisfied with the new naval shipbuilding programme of the Admiralty. This contemplates the addition of only two battleships, two armored cruisers and three unarmored cruisers, at a total cost of about ten million dollars.

The thirty-ninth meeting of the American Society of Mechanical Engineers will be held in Washington, D. C., commencing May 9. Besides an extensive and interesting professional programme, Secretary F. R. Hutton has provided for the recreation and instruction of members a series of visits and inspections of famous places in the vicinity. Additional interest is lent to this visit from the fact that Rear-Admiral George W. Melville, Engineer-in-Chief of the Navy, is the president of the Society. Among the items on the programme is a reception by President McKinley in the Executive Mansion on the afternoon of May 10. Special arrangements have been made with many of the railroads for a reduced fare for the meeting. The headquarters of the Society during the meeting will be at the Arlington, Vermont avenue and H street N. W., and here a special rate for members of the Society has been secured.

VIBRATIONS OF STEAMSHIPS AND METHODS OF BALANCING MARINE ENGINES—IV.

BY C. H. PEABODY, B. Sc.

Thus far in the discussion of balancing engines but little attention has been given to the irregularity due to the connecting-rod, although attention has been called to the fact that a greater accelerating force is required to start the piston of a vertical marine engine, down from the top of the cylinder, than is required at the lower end. The irregularity becomes more marked as the ratio of the length of the connecting-rod to the crank diminishes. Thus, with a connecting-rod seven times as long as the crank the accelerating force at the lower end is three-fourths as much as that at the upper end, while with a connecting-rod four times as long as the crank, the lower force is only six-tenths of that at the upper end. From this it appears that the methods of balancing proposed by Yarrow and Schlick are really only ways of ameliorating the ill effects felt with unbalanced engines. To show that this is no imaginary evil we may relate an experience with a set of Willans engines at an electric lighting station. The Willans engine is a single acting triple engine, with three pistons on one piston rod. The weight of the reciprocating parts is consequently relatively large, while the connecting-rod is short. These engines are usually arranged in pairs on the same bed, with the cranks opposite, in order to get the same effect as from an ordinary double acting engine. Mr. Robinson and Captain Sankey report that serious trouble was found at the station mentioned when ten such engines, each indicating 200 horse power at 350 revolutions per minute, were mounted on a large slab of concrete, which was 88 ft. long and 24 ft. wide. In the engine room there were no perceptible vibrations, but very unpleasant vibrations were experienced in houses that were 100 ft. distant. The cranks of each of the engines were only 27 in. apart, consequently it did not appear that the vibrations could be due to rocking couples, that is, to the lack of running balance. A calculation of the accelerating forces at the ends of the stroke of the piston of one engine showed that there was a force of 3.54 tons required to start the piston which was at the top of its cylinder, while only 2.31 tons were demanded by the piston at the lower end of the stroke. Consequently there was a net upward pull on the block of concrete equal to 1.23 tons, tending to lift the concrete when the pistons were at the ends of their strokes. A further calculation developed the fact that when the cranks were at 90° with the line of dead points, there was a downward thrust of 1.27 tons on the concrete. With ten engines running at about the same speed it frequently happened that several engines synchronized, and then the pull and push on the concrete set it into oscillations, for it was on a spongy foundation, and the semi-fluid nature of the foundation gave a sort of hydraulic transportation of the oscillations of the concrete slab to the foundations of the houses in the neighborhood.

Again, in both Yarrow's and Schlick's methods of balancing engines it is considered that the side throw of the bob-weight connecting-rods will take care of the unbalanced components of the connecting-rods for the several pistons. Here again we have an approximate standing balance, but not a running balance, and the side throw of the connecting-rods is likely to set up transverse rocking couples. In this statement it is to be borne in mind that Schlick's method treats some of the pistons as bob-weights for the others. This is, however, more a matter of scientific interest than of practical importance, since the rocking couples can never have an important influence.

Fig. 17 exhibits a very complete balancing of a single cylinder engine by the use of bob-weights on the opposite side of the crank shaft. Both the piston and the bob-weights are shown at the crank end of the stroke, near the crank shaft. It is evident that both

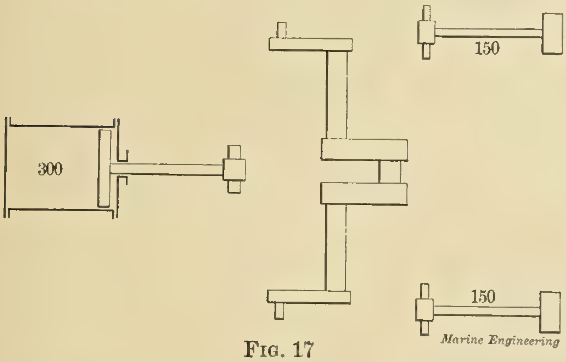


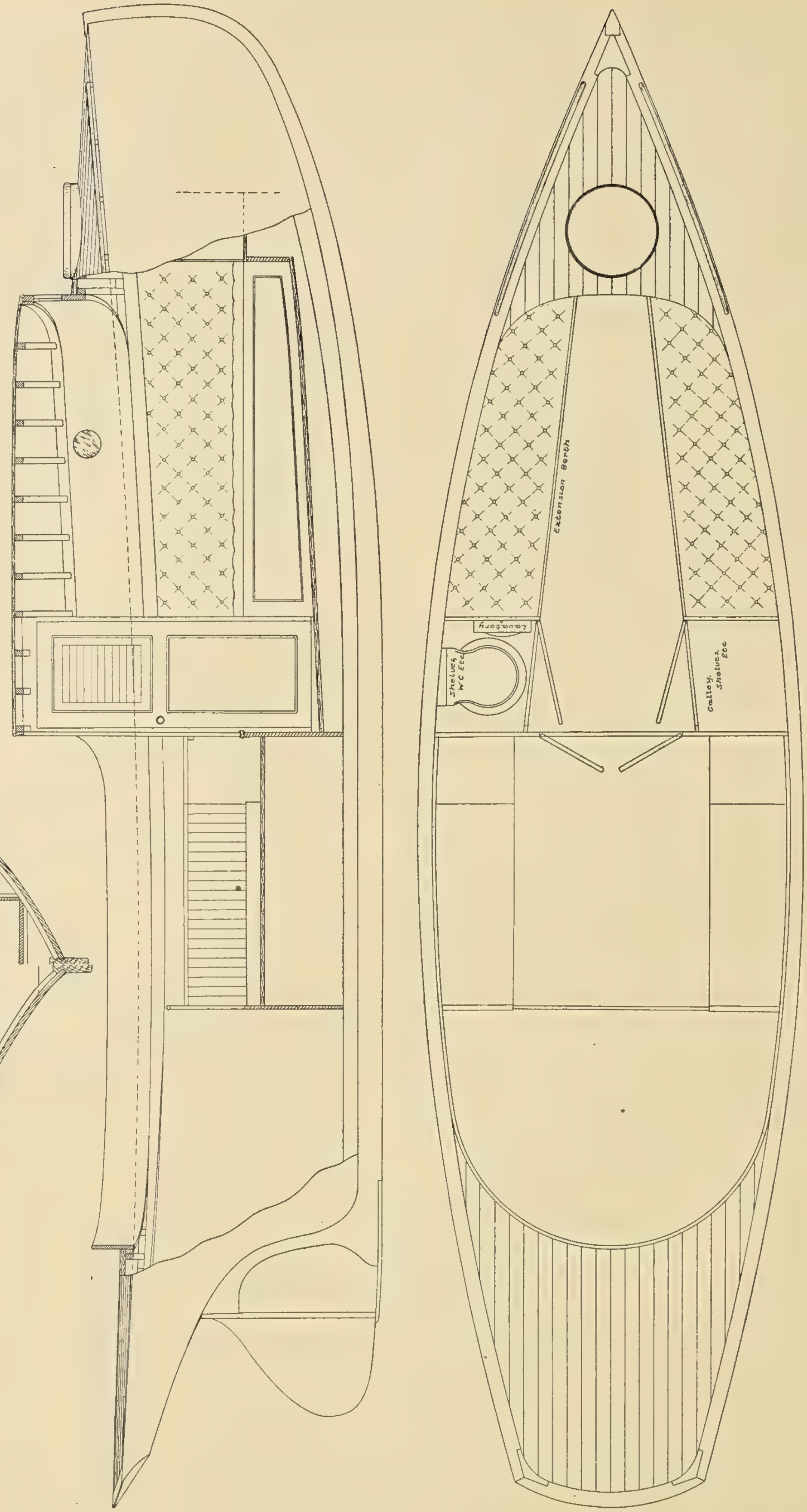
FIG. 17

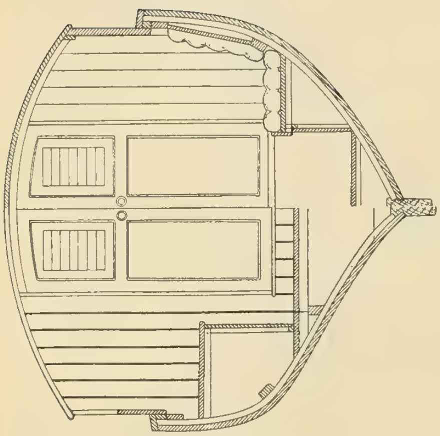
will be at the head-end or the remote end of the stroke at the same instant, and finally that the displacements from one end of the stroke will be exactly equal for all positions. Consequently the center of gravity of the system of piston and bob-weights will remain fixed in position, and there will be no unbalanced longitudinal accelerating forces. The longitudinal accelerating forces acting on the connecting-rods will also be completely balanced, but there will be unbalanced transverse accelerating forces due to the slatting of the connecting-rods. If Fig. 17 represents the plan view of a horizontal engine with bob-weights, the unbalanced transverse forces acting on the connecting-rods will tend to rock the engine bed, throwing it up at one end and down at the other. Of course a three-cylinder engine, simple, compound or triple, can be arranged on this system. A compound engine would naturally have one high-pressure cylinder on one side and two low-pressure cylinders on the other. The reciprocating parts for the high-pressure cylinders would then need to be loaded so as to weigh twice as much as those for one of the low-pressure cylinders. A triple engine might have the high-pressure and intermediate cylinders on one side and the low-pressure cylinder on the other. The distance of the high-pressure and intermediate cylinders from the line of the low-pressure cylinder should be made inversely proportional to the weights of their reciprocating parts. The reciprocating parts for the low-pressure cylinder should, of course, be loaded so as to weigh as much as the reciprocating parts of both the other cylinders. This method of balancing, though very complete, will seldom if ever be used in practice, since everything is sacrificed to the obtaining of one result. The turning effort of the engine is very unsteady, no better than that of a single cylinder engine; the general arrangement is poor, requiring a large extent of piping to lead steam from one cylinder to another; and the weight of the engine bed and of the reciprocating parts will be large. In fact, the arrangement is most interesting as showing that the complete development of one idea may destroy the symmetry and usefulness of a design.

The Willans Engine Company has made engines with six cranks and as many sets of cylinders, three in a set, which have been found to run very steadily. Each set of these cylinders forms a single acting tandem engine, consequently the arrangement with six cranks requires in all eighteen cylinders. The three cranks at one end of the shaft are set at 120°, consequently that half of the engine by itself would be very nearly in standing balance, more nearly so than the ordinary three-cylinder triple engine with three cranks. The other half of the engine also has three cranks set at 120°, and the two halves are joined together so that the cranks come in reverse order, and thus do away with rocking couples. An engine of this sort has been supplied to the Heilman electric locomotive, and drives the electric generator. The driver axles are turned by electric motors, thus involving a double transformation of energy. The leading idea in this locomotive is to avoid the various rolling, pitching and slewing motions of the ordinary steam locomotive, which may be dangerous at very high speeds. It is therefore very important that the engine which drives the electric generator shall not set up vibrations of the locomotive frame on its springs.

Should the application of gas engines to marine propulsion be developed so that they are used on large ships, then the idea just mentioned of so arranging a six crank engine as to avoid setting up vibrations may be of importance to marine engineers.

The U. S. Standard Register of Shipping for 1899-1900 has been received. This is the official publication of the United States Steamship Owners', Builders' and Underwriters' Association, Ltd., and is familiarly known as the Red Book. It is a very complete record of the scope and work of the society. It opens by a tariff of the classification fees. The rules for the construction and classification of steel and composite vessels are very completely set out and are extensively illustrated by well printed plates. Wooden vessels intended for service on the Great Lakes are also represented by various plans and sections. The list of vessels in the Register covers about 100 pages, and is followed by many pages in blank, alphabetically arranged, in which the additions made during the year can be inserted. There are many subsidiary matters in the book, such as the rules for the use of electric light on shipboard, etc. Altogether the volume is very complete and exceedingly useful for reference. The annual subscription is $10.00, and this may be forwarded to the office of the Association, in the Post Building, 16 and 18 Exchange place, New York, or to the surveyors who are stationed at New York, Newport, R. I., Baltimore, Boston, Victoria, B. C., Buffalo, N. Y., Chicago and at Liverpool, England.

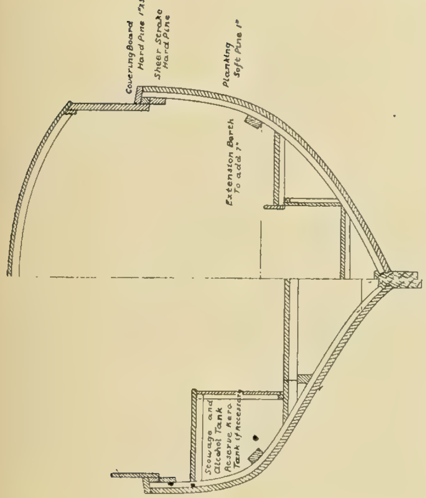


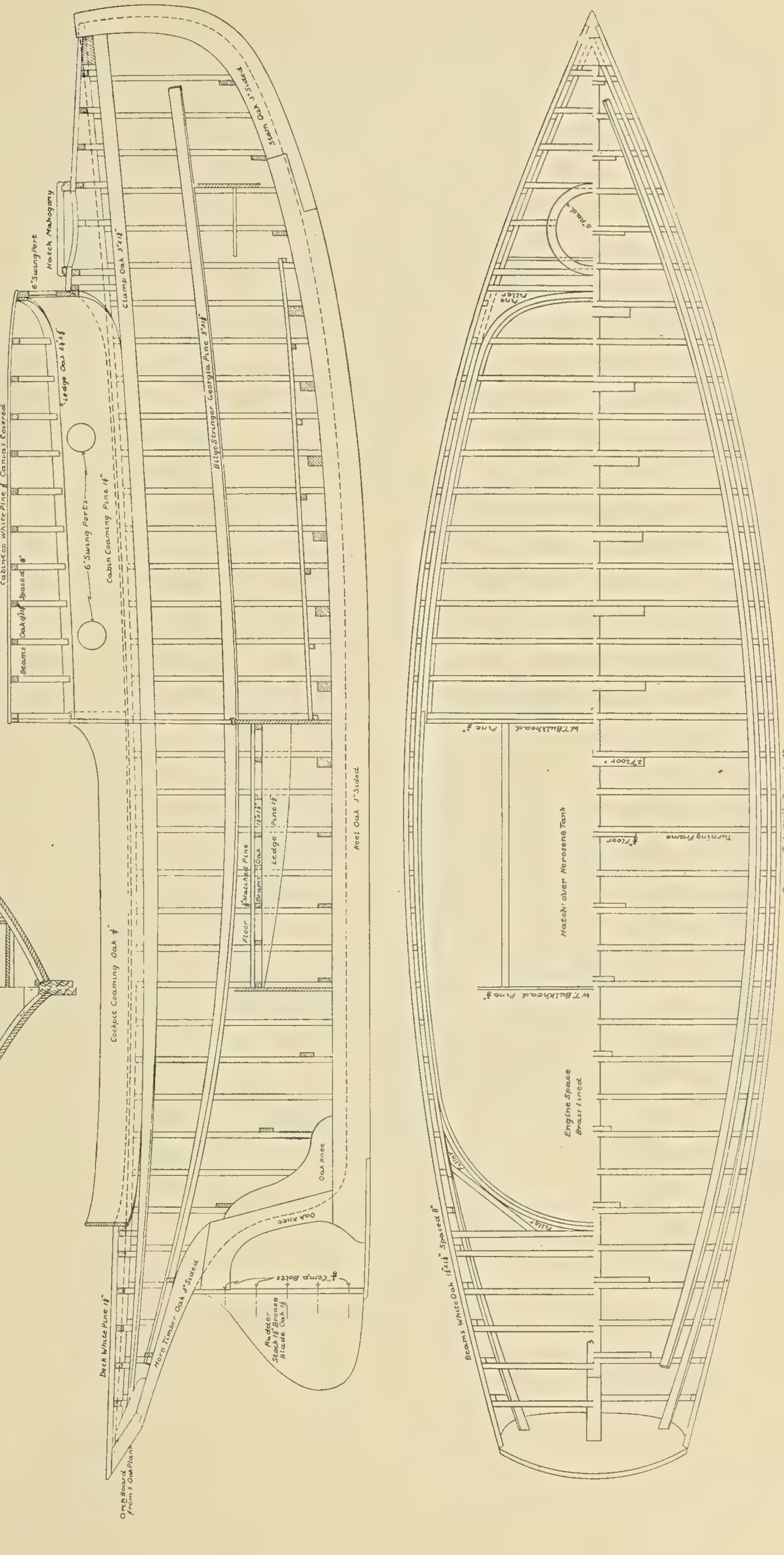


Accommodation Plans of Seagoing Motor Boat, Designed by W. B. Stearns, Marblehead, Mass.

For Description see Page 37.

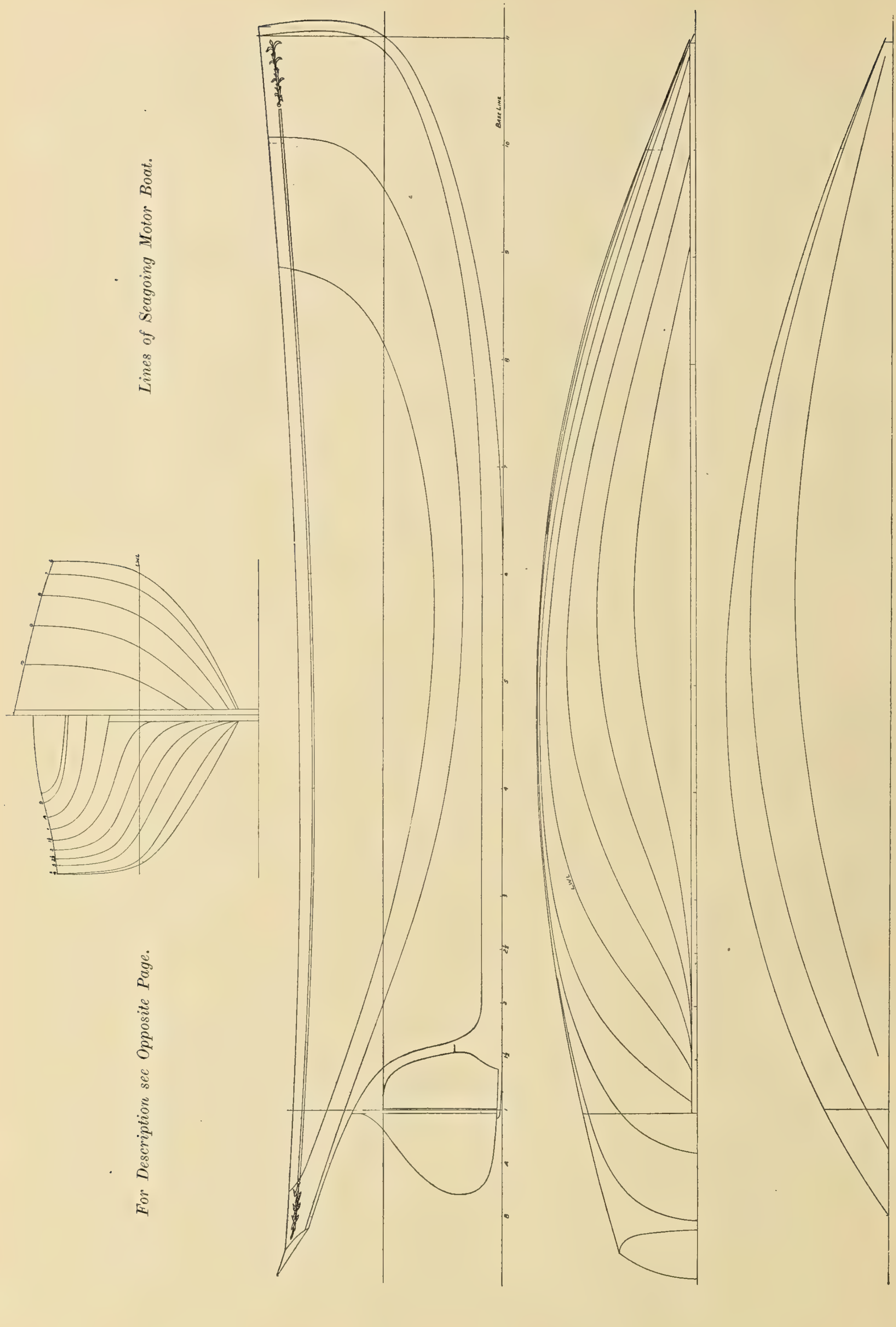
Construction Plans of Seagoing Motor Boat, Designed by W. B. Stearns, Marblehead, Mass.





For Description see Page 37.

Lines of Seagoing Motor Boat.



For Description see Opposite Page.

Motor Boat for Sea Service.

There are many persons who like to make short cruises along our coasts who do not want the expense or bother of a steam launch or small yacht, and who at the same time are not impressed with the uncertainties of sail power. For such, a cruising launch of the type here illustrated is a very satisfactory vessel. This particular boat was designed by W. B. Stearns, of Marblehead, Mass., for C. Colburn Clement, of Haverhill, Mass. She might be termed a sea-going motor boat, as she was designed for the purpose of taking her owner on short cruises on the exposed coasts of Maine and Massachusetts.

In this case the owner appreciated the need of some more scientific treatment than that which frequently results in the production of a motor boat, for which "any old model" is usually considered good enough. There were certain requirements to be met: the cost was to be kept within reasonable limits, there were to be many conveniences, which one might usually expect only in a large vessel, and the boat was to be strong, comfortable and absolutely seaworthy. The dimensions agreed upon were: Length, 26 ft.; beam, 6 ft. 9 in., and depth, 4 ft. 5 in., with closed cabin 5 ft. in the clear. To keep down the item of cost it was considered best to use a 5-horse power motor instead of 7-horse power, which would ordinarily be used in a boat of such excessive displacement. The improvement in form over the ordinary stock launch hull, however, justified the experiment, for the boat showed as much speed as could be reasonably expected of a craft of her length. Under favorable conditions she has maintained a rate of speed within a fraction of eight knots, and performed excellently in a seaway, being dry, easy in rolling, and absolutely non-capsizable. In a general way the plans here published show the accommodations. The large locker on the starboard side is fitted very ingeniously and completely as a galley, with all the implements necessary for cooking for two persons. The folding lavatory in the toilet compartment, within reach of the galley, is connected by a pump with the fresh water tank, draining directly outboard. This, however, while adding to the convenience of the cook, does not conduce to economy of water. The two sofas in the cabin are fitted to extend so as to make comfortable beds, and numerous lockers are provided for bedding, clothes, etc. The ice box is placed under the seat in the cockpit.

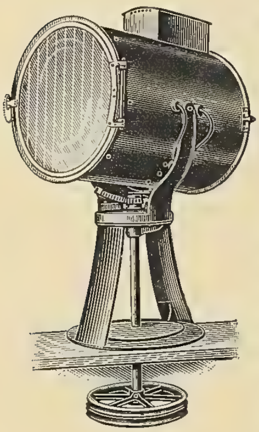
CRUISING LAUNCH FOR SEA SERVICE, FITTED WITH ALCO-VAPOR MOTOR.

This boat was built by John Stewart, of Wollaston, and the machinery, consisting of an Alco-vapor motor and propeller, etc., was supplied by the Marine Vapor Engine Co., of Jersey City, N. J.

IMPROVED APPARATUS.

Benton Projector Case.

Our illustration shows a new type of projector search light case made by Thomas P. Benton & Son, of La Crosse, Wis. The case is made of heavy gal-



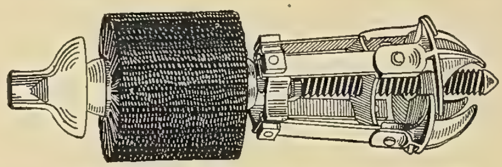
vanized steel reinforced at proper points by angle iron hoops which make it extremely rigid. The hinges and fastenings on both doors are brass and of large size. The pedestal is arranged to bolt to the deck or platform which supports the light, and is shaped so as to be rigid and shed water and also prevent leaking through. The tubes on which are fastened the controlling wheels pass down through the pedestal. (The wheels can be placed between the two pedestal sides if occasion requires.) They can be placed close up to the deck and are connected to the handling device in the pilot house by small wire ropes. The wheels can be boxed in and the ropes pass through mouldings, making a neat job. When it is desired to place the light directly over the operator, as on the top of the pilot house, the regular handling wheels are fitted on in place of the rope sheaves. In the pilot house there is placed a device with two drums, around which passes the cables from the rope sheaves. When both drums turn together the light is swung maintaining the angle of deflection to which it is set. A device is provided to change the relation of these drums, which changes the angle of deflection to the one desired. The cut shows a case made with 20 deg. range of deflection both ways from a horizontal line. This would make the center of the ray of light strike the water 55 ft. from the lamp, the projector being 20 ft. above the water.

Combination Flue Brush and Scraper.

This is a new combination of flue brush and scraper manufactured by the St. Louis Steel Wire Brush Co., 620 North Main street, St. Louis, Mo. The scraper cuts the scale off the tubes, which is then pushed out of the tube by means of the steel brush shown, the tube being cleaned in one operation. The scrapers are made of malleable iron and carried on four steel arms and fastened in the center. They are expanded or contracted by turning the rod to the right or left, thereby moving the slide up or down on the threaded rod in the center. The brush is made of fine tempered steel wire, the wires passing entirely through the holes in the iron center and being fastened on the inside, making it impossible for them to come out or lay over, the whole construction being of the best, and designed for hard and rough usage.

Gas Engine Ruhmkorff Coil.

The Varley Duplex Magnet Company, 138 Seventh street, Jersey City, N. J., has brought out a new induction coil for use in igniting the charge in marine gas and gasoline engines, an illustration of which is presented herewith. These coils are built to give a spark 1 to 1 1-2 in. long, with a primary pressure of 4 to 6 volts. It is stated that with the discharge points 3-32 in. apart the flame is very intense, and the ignition is positive beyond any chance. The make-and-break device in the primary of the coil is located outside the cylinder so as to be easy of access. The manufacturers state that the price of the coil is such as to justify its use for ignition purposes by engine builders who have used other methods because

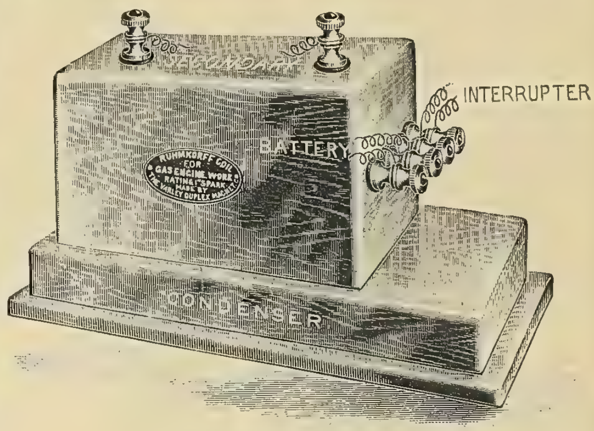


COMBINATION FLUE BRUSH AND SCRAPER.

of low first cost. They further claim that these coils possess points of superiority over those of foreign make heretofore used.

Automatic Check and Stop Valve.

The accompanying engraving shows an automatic check and stop valve designed and manufactured by F. Hennebohle, of Chicago. This form of non-return valve is made extra heavy for high boiler pressure. It is guaranteed in operation to automatically close when the pressure in the boiler falls nalf a pound below the pressure in the main, and yet not be affected by the ordinary pulsations, and to remain noiseless in operation. When in operation the tendency of the valve is to keep near its seat, and where these valves are fitted to a set of boilers, should a sudden demand for steam be made from the engine, each valve will

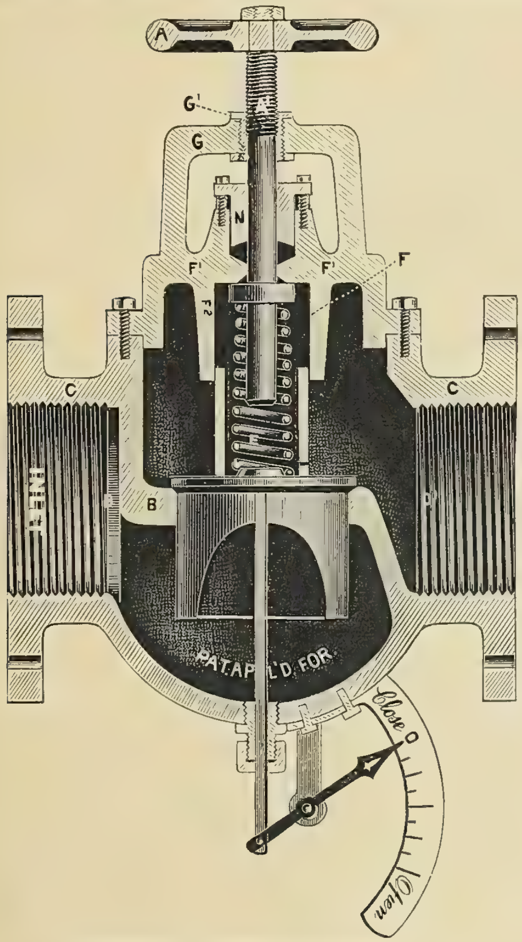


VARLEY RUHMKORFF COIL.

respond equally, and thus, the manufacturer claims, the danger of foaming will be minimized, if not altogether got rid of. Each complete valve is fitted with an indicator so that the opening at any moment can be readily seen and a line obtained on the working of each boiler. In case of mishap to one boiler this valve, if fitted, would isolate it from all the other boilers on the ship, automatically. The manufacturer's address is South Chicago and Erie aves., South Chicago, Ill.

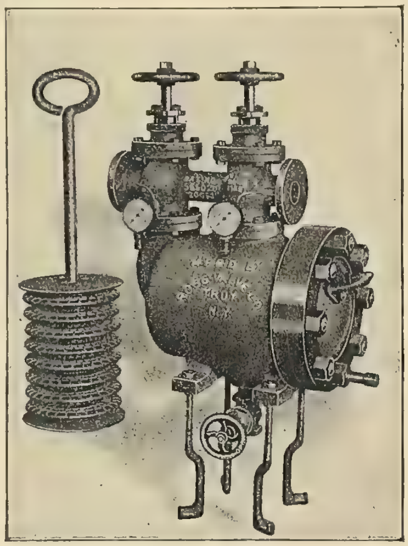
Ross Feed Water Filter.

A well equipped steamer with surface condensing engines carries a feed water filter. The grave dangers which the entrance of oil, in suspension in the feed water, into the boilers occasions are well appreciated by sea-going engineers, and feed filters from being looked upon as luxuries have taken their place as part of the necessary engine room equipment. The apparatus exhibited here is made in this country by the Ross Valve Co., of Troy, N. Y. The filter is placed between the feed pumps and the boiler, and consists essentially of a chamber containing a bag made of the fabric known as "Turkish toweling," so folded as to obtain a large area of filtering surface in a small space. The surface of the bag is formed into a series of deep circular corrugations by being drawn over a bronze skeleton shown in the exterior view, and drawn down between each of the sections



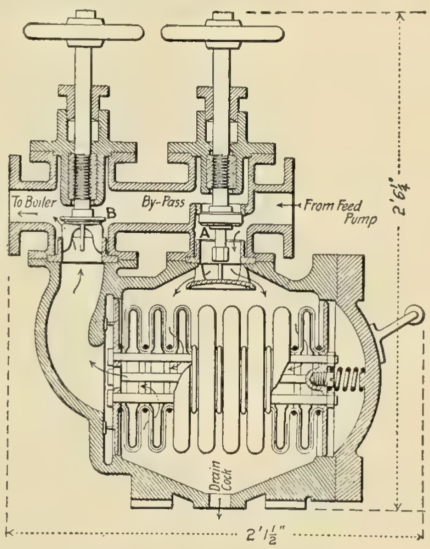
HENNEBOHLE CHECK AND STOP VALVE.

by means of strings wound around it. The area of the filtering surface is made from 250 to 1,000 times the area of the feed pipe, according to the service required. The threads of the Turkish toweling retain the oil until they become saturated with it, while they let the water pass through. The filter is so constructed that the water passes from the outer side of the bag through it and the metal skeleton to the interior of the latter, and thence to the outflow pipe, as shown. The oil gradually clogs up the filtering material, increasing the resistance to the passage of the water. This resistance is indicated by the difference in the readings of the two pressure gauges, one on the inlet and one on the outlet side of the filter. When the difference in pressure reaches 2 or 3 lb. per sq. in. the filter may be cleaned by reversing the direction of the current, allowing the wash water to run to waste, or by changing the filter bag, a fresh one always being kept in reserve. The head of the filter chamber may be opened, the filter bags changed,



ROSS FEED FILTER.

the skeleton and the bag being removed and it and the head replaced inside of five minutes. The washing of the filter by reversing the current of water is done by operating the valves in the following manner: The inlet valve, *A*, is first screwed down and closed; *B* is then closed, and the drain cock opened.

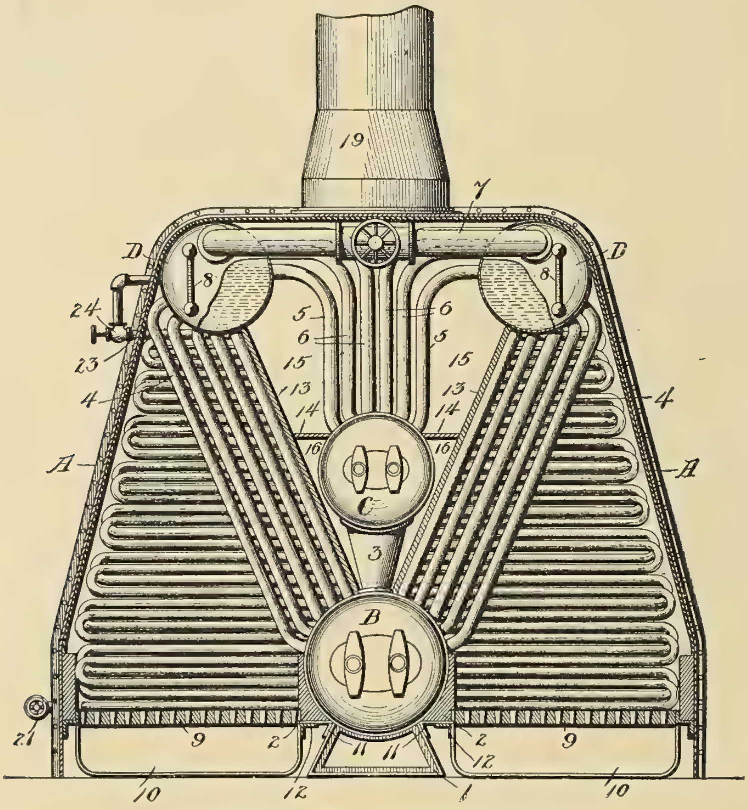


SECTION OF ROSS FILTER.

Valve *A* is then opened a little and the current of water thus created washes the outside of the filter. *A* is then closed and *B* opened, causing water to pass from the boiler through the filter bag from the inside. The valve, *A*, is ingeniously made to perform the double function of a stop-valve and a by-pass valve, as shown in the sectional drawing.

Keene Water-Tube Boiler.

A new type of high pressure water-tube boiler for marine use has been patented under the name of the "Keene Marine Boiler." As shown in the engraving, it consists of one lower, one central and two upper drums connected by banks of tubes, the central and lower drums being connected by three large tubes or water legs (*3*). A fire-box is located on each side of the lower drum. The casing is of sheet iron lined with asbestos. By means of suitably arranged tiling the products of combustion are made to pass three times through the boiler, first under the tiling (*13*) which covers the two lower banks of tubes to the back of the boiler, thence over this tiling and under the horizontal tiling (*14*) to the front, thence to the back of the boiler over the tiling (*14*) and out through the stack, which is situated at the back of the boiler. boxes, the entire structure being surrounded by a casing of sheet iron lined with asbestos. Without departing from this claim, the sizes of the drums and tubes and the number of the latter can be changed to conform to particular requirements. It is, however, intended that the drums shall be sufficiently large for a man to enter them, and that the tubes shall be of the "large type." For abstracting the steam, a dome, drum or two separators can be used. As shown in the engraving, there is a double row of interlocking pipes which form a protecting wall at the back of the boiler; these comprise the feed water heater. The coils are connected with the pump, the lower drum, and with one or both of the upper drums. When not feeding water into the boiler the valve or valves (*24*) are kept open so that there shall be a circulation between the upper and lower drums

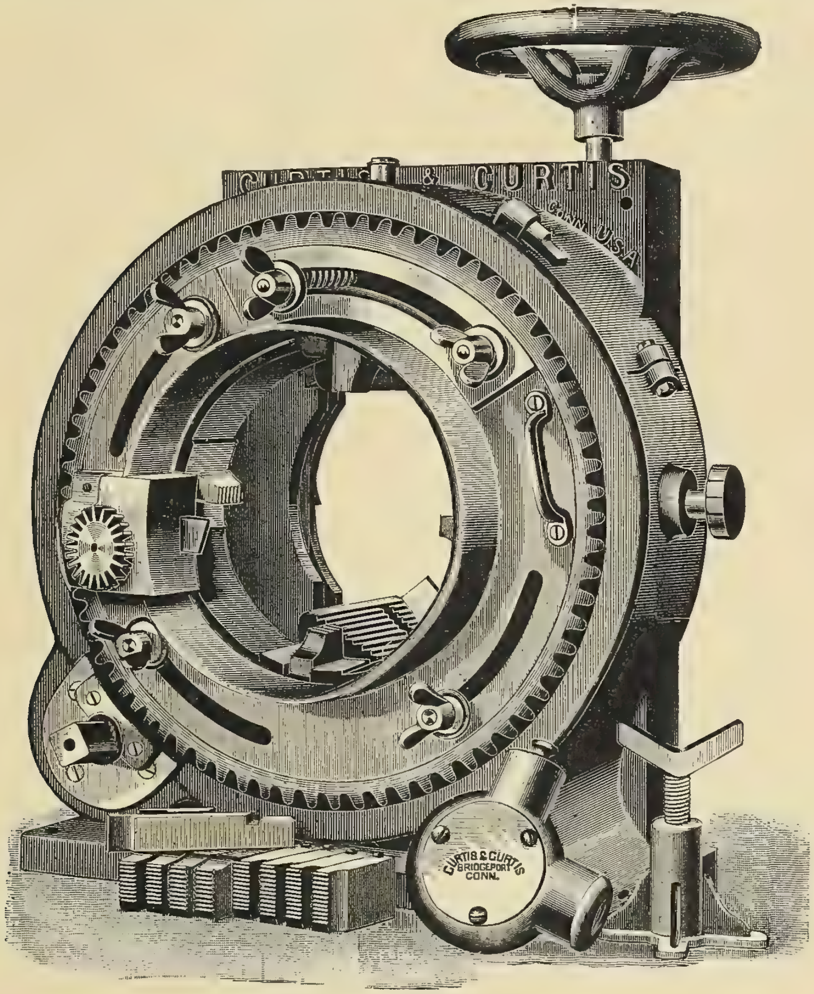


KEENE MARINE WATER-TUBE BOILER.

The circulation is arranged as follows: the water ascends from the lower drum through the outer or lower banks of tubes (*4*) to the upper drums, then descends through the tubes (*5*) to the central drum, and from there through the large legs (*3*) into the lower drum, and so on in continuous circuit. The steam generated in the lower drum, the central drum and the three water legs connecting these two drums finds an easy escape through the upper tubes (*6*), which are not submerged, these being utilized as steam superheating surfaces. The principal patent claim is for a boiler consisting of a central drum, around which are grouped three other drums in triangular arrangement, the drums being connected by banks of tubes and one drum being between two fire- through the coils of the heater. The advantages claimed for this boiler are many: perfect circulation, large grate area and large heating surface, thorough utilization of heat, economy, high pressure, safety, quick steaming, lightness, adaptability to large units, high efficiency, maximum power and minimum weight and space. Further particulars can be obtained by communicating with George J. Rockwell, 631 Washington Boulevard, Chicago, Ill.

Forbes' Patent Die Stock.

To produce a machine which, according to its size, will thread pipe from 1-4 in. to 12 in. dia., and yet be quite portable and easily operated, has been the aim of the designer of the Forbes Patent Die Stock here shown. The labor attendant on the use of ordinary hand die stocks is familiar to many of our practical readers, and in large work this method is really out of the question. Large stationary power machines, while very effective, have the disadvantage that the work must be brought to them instead of the machine being taken to where the work is going on. The illustrations here printed show Forbes' Patent Die Stock. It consists of a die-carrying gear supported and surrounded by a shell and actuated by a small pinion embedded in the side of the shell and working on the large gear, with the pipe vise attached to the back of the machine. To operate it, the pipe is placed through the pipe vise with the end to be threaded against the back of the dies. The die-carrying gear is then revolved by means of a crank on the end of the pinion. As the dies revolve the gear is drawn back into the shell and the dies are thus brought on to the pipe. These dies are adjustable to any variations of fittings, and, when the thread is cut, they can be opened and the pipe taken out without running back or stopping the machine. In cutting off pipe the gear is shoved back in the shell and held by a stop, so as to give it a rotary without a traveling motion. A blade cutter is then inserted in the gear, which is automatically fed forward as the gear revolves. The advantages claimed for this machine are: It is portable and can be carried from place to place and the pipe cut on the spot without the delay and expense of carrying it to the machine. This is very valuable for marine use, as a machine with a capacity even for 12 in. pipe can be carried on shipboard in very small space, and repairs made by the engineering force while at sea. In case it is desired to thread the end of a pipe without disconnecting it and where only one end is exposed, the machine can be slipped on and the work done without taking the pipe down. With this machine pipe even as large as 12 in. can be threaded by one man. Dies can be sharpened by grinding without first drawing the temper, and when one of the set is lost or broken a new one can be supplied without replacing the set. They draw back out of the way when thread is cut, yet always cutting standard sizes, and are adjustable to any variations of fittings. The shells are adjustable for wear, which greatly prolongs the life of the machine. By the addition of a cast-iron base, with necessary gearing and countershafting, the machines can be fitted to run by power, so that they can be used by power as a power machine in the shop or taken from the base and used on outside work as a hand machine. The machines are manufactured by Curtis & Curtis, Bridgeport, Conn.



FORBES' PATENT DIE STOCK.

MARINE ENGINEERING

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In response to the kind inquiries of friends we are happy to be able to state that Mr. H. L. Aldrich has made an exceedingly rapid recovery from the effects of the severe accident which he recently met with, and that he will be able soon to personally express his appreciation of the many sympathetic messages which we have received.

YACHTSMEN and the sport loving public on both sides of the Atlantic are just now deeply interested in the two vessels which will compete this summer, in home waters, for the America's cup. The Columbia, which is to defend the cup, is now under construction at Herreshoff's, Bristol, R. I., and the Shamrock, with which Sir Thomas Lipton, the cup challenger, expects to carry home the trophy, is now building at Thornycroft's, London. Notwithstanding the great feeling of interest manifested by the peoples of the two greatest sport loving nations, it seems to be the chief desire of persons on both sides of the Atlantic who are concerned with the construction of these yachts to withhold all accurate information about them. For this cause those interested have to depend upon conjecture, misinformation and downright untruth, which the press scatters broadcast, for particulars of the design, construction and equipment of these vessels. It might be argued that outsiders have no right to any knowledge of the vessels, and this would be true undoubtedly were it the custom to carry out the contests privately. When the races are to occur, however, the public is duly notified and the race managers understand that thousands of persons will pay handsomely for the privilege of witnessing the matches. In this way the cup contest has come to have a quasi-public character. What object then could the cup contestants have for going to such extremes to hide all details of their plans? Within reason there is only one explanation: that both parties are afraid of each other; that neither will give any details for fear the other will at once incorporate such in his plans, or that he will take some unfair advantage—truly a sportsmanlike spirit! We have no inside information as to where the responsibility must be laid, in either case, for this unsportsmanlike, unscientific and illiberal conduct. The position of a croaker is neither pleasant nor popular, but we do not hesitate to say that a contest begun in such a spirit of empiricism does not give promise of that noble and fraternal conduct which should make the conclusion of this international event. It is worth while to examine further into the strange situation. Our British cousins seem on this occasion to have taken the lead in secretiveness. Only lately news was cabled of the arrest of two unoffending persons who were deprived of their liberty because they happened to be in a boat on the river in the vicinity of the works where the Shamrock is building and had a camera in their possession. It is to be assumed in each case that the designer is at the top of his profession and consequently has his own ideas of model and material. Is it, therefore, reasonable to believe that either designer would slavishly imitate his competitor? Would he adopt some feature of design, not knowing what relation it bore to the design as a whole, or to what extent such fraction of design was interdependent on the other components of the vessel for the result in its entirety? Idiocy can imitate, brain only can originate, and no one on either side of the Atlantic is going to win the races by mediocrity. It would be unreasonable, perhaps, to expect that the contending parties would disclose all their plans. Yet a true sportsmanlike spirit would give those interested a general idea of the vessels, and would at the same time maintain a discreet silence as to what the vessels might be expected to do: something that only trial can tell. There is no secret, of course, as to the determination of both contestants to win—the foundation of all sport. We have gone into this at some length for the purpose of calling attention to a narrow spirit in vessel construction which we deplore, and also for the sake of the contrast which such a spirit offers to the spirit of our Navy. We believe there is nothing that contributes more to the glorious memory of our recent victories than the remembrance of the noble and truly sportsmanlike spirit which characterized the conduct of our Navy throughout. Prior to the war it was possible for our late enemy to not only become familiar with the construction of our vessels in detail, but to thoroughly understand their performances, and to verify most of the information by personal inspection. There is no finer courtesy afloat than is to be found on the American man-of-war. In the Government publications and in the proceedings of the learned societies there is full and free discussion of the merits and limitations of our ships. In effect the Navy says: "You can have all the information you want about our ships, but don't forget that when the time comes we will lick you to a standstill." There is no secrecy, no hugger-mugger, no effort to take advantage or to spring some unlooked for device at the last moment, but with open hearts and manly courage our sailors take their ships into the race that leads to death or victory. So long as this spirit animates our sailors so long will the American Navy be invincible. Search the pages of history for a finer example of chivalry and you will not find it even in the chronicles of the crusades. To dwell on this manifestation of National character incites such feelings of love of country and pride of race as are beyond all human expression.

IN our educational department in this issue the reader will find an extremely interesting paper on sketching by Professor C. W. MacCord, which, though one of a series primarily intended for beginners, can be read with profit by the most experienced. There are one or two points made by the author, who, by the way, is one of the greatest living authorities on all matters pertaining to engineering drawing, that should find a place in the notebook of every engineer. One is that the drawing or sketch should be such that by its aid the workman can make what is required without the possibility of mistake. Any one who has had much practical experience will recall cases in which a drawing was not of this kind. The three most frequent causes of error, perhaps, are insufficiency of detail, or the reverse—over-elaborateness of detail and thus confusion—and the unfamiliarity of the draughtsman with workshop limitations. The first two can be more easily guarded against than the last, unless the designer has had sufficient shop experience. The lack of this is responsible for much labor wasted on drawings for impossible castings, that no foundry could turn out, or on engine parts that no machine in the builder's shop could handle, at least with anything like economy. The misuse of materials and the lack of sufficient clearance for moving parts are also common errors. The error of leaving out necessary details is most common with beginners, who often assume that because they are perfectly familiar with the object sought to be represented the mechanics in a shop, say 1,000 miles away, should be equally informed. Marine engineers who are often far distant from shops in case of breakdown cannot be too careful in this respect. The experienced draughtsman, on the contrary, too often goes to the other extreme and gets out most elaborate plans, works of art in fact, which are practically worthless. This is frequently due, as Professor MacCord points out, to the use of unnecessary dotted lines. In the end elevation of an engine, for example, dotted line is laid on dotted line until the drawing looks like a tangled skein of thread, and probably not even the draughtsman himself could, after a lapse of time, take off the dimensions with a scale. This is especially annoying and misleading when blueprints are used. The shrinkage of the print is such that the drawings cannot be read by scale and there is no room for figured dimensions. Most of the troubles with drawings arise from a misconception of their purpose. The trained draughtsman who is confined to the board often grows into the belief that the end and aim of his work is to produce fine drawings, whereas in reality his work is only a means to an end—the satisfactory construction of an efficient and economical machine with the facilities at hand.

IN commenting upon the new Naval programme in our last issue the number of protected cruisers provided for was given as three. This is an error, as the correct number is six, which, with the three battleships and three armored cruisers, makes a total of twelve new vessels. The Navy Department originally recommended the construction of fifteen vessels, but Congress in its wisdom cut this down to twelve ships nominally and six practically, as the armor plate restriction holds up indefinitely the construction of the three battleships and three armored cruisers. Meanwhile it is a consolation to know that our Navy will soon be strengthened by the addition of several vessels now under construction.

MARINE BREAKDOWNS AND LOSSES.

S.S. Norseman Ashore at Marblehead.

The Warren line steamship *Norseman* went ashore in a fog on Marblehead Neck early in the morning of March 29 while trying to make Boston harbor without a pilot. The shore here is unusually rocky, with boulders scattered about on the bottom into deep water. She struck about 500 yards off shore and filled, so that she drew 31 ft. forward and 19 ft. aft, about 100 ft. of her keel from the stern post forward overhanging a ledge on which she lay. The life saving crew was promptly in attendance, and the crew and officers were taken ashore in the breeches buoy. The captain was the last to leave, and his journey toward the shore is depicted in the reproduction of the snapshot here printed.

As soon as the owner's agents were notified they enlisted the services of the Boston Tow Boat Company, and Captain William I. Humphrey, of that well-known wrecking concern, went down to make a survey of the *Norseman.* As a result it was decided to put large centrifugal pumps aboard and attempt to drain the vessel. She has seven watertight compartments and in each a pump, with a capacity of ten tons a minute, was placed in the 'tween decks. On the upper deck a boiler was placed for each pump. It was then found that the pumps could reduce the water in all the holds except the forward one, and here the pump was not able to make any impression. Pumping was here discontinued and the hatches were put on in the lower 'tween decks and shored down, and the same treatment was applied to the deck all over, so that the vessel could float on that deck at the forward end. Divers were also sent down, but they could not accomplish anything, as the wounds were all under the ship. The wreckers next laid anchors and cables out astern of the ship, about four points on the port quarter, so as to haul her off clear of Tom Moore's rocks, inside of which the *Norseman* lay. At the first tide the vessel was hauled about 50 ft., which was sufficient to haul her bow out of the hole in which it rested and put the ship more nearly on an even keel. Divers were now able to get at the holes in the bottom and to fill some of the holes with oakum, blankets, plugs and wedges, and so check the inflow that the pumps could reduce the depth of water in the holds very considerably. Meanwhile the cargo was being pulled out and discharged into lighters alongside and towed to Boston. At the next high tide, though the vessel was drawing 23 ft. forward, 19 ft. aft and 18 ft. at the bridge, the wreckers hauled her toward deep water about 60 ft. This process was repeated at the next following high tide, and finally on the morning of April 7, with the assistance of some ocean swell that was rolling in, the *Norseman* was floated. She was then towed to the Simpson dry dock, in Boston, and docked for a survey by the underwriters' representatives. The damage she sustained was very serious, as a little forward of amidships her entire bottom was almost torn out. The vessel had a mixed cargo, insured for $250,000. It consisted in part of china clay and bleaching powder, which were destroyed, and wool and textile fabrics, which were much damaged.

The *Norseman* is a four-masted iron single-screw vessel of 4,550 tons register, built in 1882 by Laird Bros., Birkenhead-on-the-Mersey. Her dimensions are: Length, 392 ft.; beam, 44 ft.; depth, 25 ft. She is fitted with compound engines, with cylinders 48 in. and 85 in. by 60 in. stroke. She was classed 100 A1 at Lloyds.

Boiler Explosion on H.M.S. Terrible.

As a result of the coroner's investigation into the recent fatal accident on the British cruiser *Terrible* a verdict was rendered by the jury exonerating the officers of the vessel and recommending that the Admiralty discontinue the use of welded boiler tubes. The evidence showed that the explosion occurred while the cruiser was steaming at about the rate of 14 knots on her return trip home from Malta. The engineer officer who was on watch testified that he heard "a hissing noise" in one of the boilers, and fearing that a leak had developed he gave the order to draw fires. One of the firemen in obedience opened the furnace door, and instantly there was a loud report, and steam and flame came out through the door in an explosive blast. The section of the stokehold in which the boiler was located instantly became filled with steam, and men from an adjoining compartment groped their way in and dragged out the firemen who had been injured; the stoker who had opened the door suffered fearfully, and died soon after being taken to the sick bay.

The witness believed that the failure of the tube had been caused by deterioration of the metal owing to the work it had gone through. The tube was of the welded variety, and he believed that solid drawn tubes were more reliable. It also developed in the inquest that on the outward trip of the *Terrible* a tube had burst and two men were slightly scalded as a result. In all three tubes "had gone" during the voyage. The disaster caused a temporary panic, and it was difficult to get the men to stand up to their work afterward, and when firing they endeavored to keep as far from the furnace doors as possible. The mishap was also variously credited to shortness of feed water, and to leaky condensers, which permitted salt to get into the boilers. At the time of the mishap the gauge pressure was only 180 lb. per sq. in.

The *Terrible*, as most of our readers are doubtless aware, is one of the two largest cruisers afloat, and she has always been looked upon as an experiment in many respects. Her machinery has given more or less trouble since she was put in commission. She was built at Clydebank in 1895, and is a protected cruiser of these dimensions: Length, 500 ft.; beam, 70 ft.; draught, 27 ft.; displacement, 14,200 tons. Her twin screw engines are of the four crank triple-expansion type, giving 24,000 I. H. P. collectively with induced draft, and a speed of 22 1-2 knots. She is fitted with forty-eight Belleville water-tube boilers, placed in eight compartments, with a total grate surface of 2,200 sq. ft. and heating surface of 67,800 sq. ft. She has four funnels and two military masts, and is altogether a huge and powerful looking war vessel of the cruiser type.

Inquiry into Loss of S.S. Londonian.

The British Board of Trade has held an inquiry into the loss of the British steamship *Londonian,* 5,000 tons, at sea, and found that the ship was in every way well found and well built. Her loss is attributed indirectly to a bunch of cotton waste. The vessel was fitted with a steam steering gear which employed a tooth quadrant and gear. When one of the crew was cleaning up he left a handful of waste in the case which inclosed the gear, with the result that later it worked in between the circular rack in the quadrant and the driving pinion and locked the gear. This occurred at a critical moment, when a gale was blowing and the sea was running high. Before the rudder could be got to move again the ship fell off into the sea and both cattle and cargo shifted to leeward. The vessel was in consequence so inclined that the sea cocks were above water and the engines had to be stopped for lack of circulating water for the condensers. By this time the vessel had become unmanageable, and was finally abandoned in mid-ocean. The breakdown of steering gear on large steamships, from one cause or another, in bad weather, has become of late a matter of frequent occurrence. In some instances the vessel, being fitted with twin screws, was enabled to keep steerage way until repairs could be made or the supplementary hand gear put into service.

The *Londonian* was a four masted steel steamer, in dimensions: Length, 450 ft.; beam, 49 ft.; depth, 30 ft. 9 in.

EDUCATIONAL DEPARTMENT.

HELPS FOR CANDIDATES FOR MARINE ENGINEERS' LICENSES—MATERIALS OF ENGINEERING CONSTRUCTION—III.

BY DR. WILLIAM FREDERICK DURAND.

(12) *Various Specifications for Structural Steel.*

U. S. NAVY.

COMPOSITION OF BOILER PLATES.

Phosphorus: Not over .035 of one per cent.
Sulphur: Not over .040 of one per cent.

Elastic Limit: Not less than 35,000 lb. per square inch.

Cold Bending Test.—One piece cut from each shell and curved head plate, as finished at the rolls for cold-bending test, must bend over flat on itself without sign of fracture.

STRENGTH OF FURNACE AND FLANGE PLATES.

Tensile Strength: Between 52,000 and 60,000 lb. per square inch.

Elongation: Not less than 26 per cent in 8 in.

Quenching Test.—One piece shall be cut from each furnace or flange plate as finished at the rolls for quenching test, and after heating to a dark cherry red,

VIEWS OF THE S.S. NORSEMAN ON THE ROCKS AND THE CAPTAIN COMING ASHORE IN THE BREECHES BUOY.

STRENGTH OF SHELL PLATES.

Tensile Strength: Between 65,000 and 73,000 lb. per square inch.

Elongation (transverse): Not less than 22 per cent in 8 in.

Elongation (longitudinal): Not less than 25 per cent in 8 in.

plunged into water at a temperature of 82 deg. F. The piece thus prepared must be bent double round a curve of which the diameter is not more than the thickness of the piece tested, without showing any cracks. The ends of the pieces must be parallel after bending.

BOILER RIVETS.

Kind of Material.—Steel for boiler rivets must be made by the open-hearth process and must not show more than .035 of one per cent of phosphorus, nor more than .04 of one per cent of sulphur, and must be of the best composition in other respects.

Tensile Tests.—These specimens for rivets for use in the longitudinal seams of boiler shells shall have from 62,000 to 70,000 lb. per square inch tensile strength, with an elongation of not less than 25 per cent in 8 in.; and all others shall have a tensile strength of from 54,000 to 62,000 lb. per square inch, with an elongation of not less than 28 per cent in 8 in.

Shearing Tests.—From each heat, rivets must show a shearing strength of at least 51,000 lb. per square inch for rivets to be used in longitudinal seams of boiler shells, and at least 44,000 lb. per square inch for all other boiler rivets. Rivets to be driven at the same heat used for working.

Hammer Test.—From each lot six rivets are to be taken at random and submitted to the following tests:

(a) Two rivets to be flattened out cold under the hammer to a thickness of one-half the diameter of the part flattened without showing cracks or flaws.

(b) Two rivets to be flattened out hot under the hammer to a thickness of one-third the diameter of the part flattened without showing cracks or flaws—the heat to be the working heat when driven.

(c) Two rivets to be bent cold into the form of a hook with parallel sides without showing cracks or flaws.

RODS, SHAPES AND FORGINGS FOR BOILER BRACING.

Kind of Material.—Steel for stay rods and braces must be made by the open-hearth process, and must not show more than .035 of one per cent of phosphorus, nor more than .04 of one per cent of sulphur, and must be of the best composition in other respects.

Treatment.—All material for boiler bracing must be annealed after working.

Tensile Test.—Bracing coming into contact with the fire must have a tensile strength of from 50,000 to 58,000 lb., and an elongation of not less than 28 per cent in 8 in., or of 33 per cent in 2 in. in case 8-in. specimens can not be secured. Other bracing must have a tensile strength of not less than 65,000 lb., and an elongation of not less than 24 per cent in 8 in., or of 30 per cent in 2 in. in case 8-in. specimens can not be secured.

Bending Test.—One bar 1-2 in. thick, cut from each lot of the bracing coming in contact with the fire, must stand bending double to an inner diameter of 1 in. after quenching in water at a temperature of 82 deg. F., from a dark cherry-red heat without showing cracks or flaws. A similar piece cut from each lot of the other bracing must stand cold bending double to an inner diameter of 1 in. without showing cracks or flaws.

Opening and Closing Tests.—Angles, T bars, etc., are to be subjected to the following additional tests: A piece cut from one bar in twenty to be opened out flat while cold; a piece cut from another bar in the same lot shall be closed down on itself until the two sides touch without showing cracks or flaws.

CONNECTING AND PISTON RODS AND VALVE STEMS.

Tensile Strength: Not less than 80,000 lb. per square inch.

Elongation: Not less than 26 per cent in 2 in.

Elastic Limit: Not less than 50,000 lb. per square inch.

Bending Test.—One longitudinal bar 1-2 in. thick, cut from each forging, must stand bending double, when cold, to an inner diameter of 1 in. without showing cracks or flaws.

THRUST LINE AND PROPELLER SHAFTING.

Tensile Strength: Not less than 80,000 lb. per square inch.

Elongation: Not less than 25 per cent in 2 in.

Elastic Limit: Not less than 50,000 lb. per square inch.

CRANK SHAFTS.

Tensile Strength: Not less than 58,000 lb. per square inch.

Elongation: Not less than 30 per cent in 2 in.

Bending Test.—Bars 1-2 in. thick, cut from each length of shaft, must stand bending double to an inner diameter of 1 in. without showing cracks or flaws.

STEEL CASTINGS.

Phosphorus: Not more than .06 of one per cent.

Tensile Strength: Not less than 60,000 lb. per square inch.

Elongation (for moving parts): Not less than 15 per cent in 8 in.

Elongation (other castings): Not less than 10 per cent in 8 in.

Bending Test.—A bar 1 in. square shall bend cold without showing cracks or flaws, through an angle of 120 deg. for castings for moving parts of machinery, and 90 deg. for other casting, over a radius not greater than 1 1-2 in.

U. S. INSPECTION REQUIREMENTS FOR BOILER PLATE.

Phosphorus: Not more than .06 of one per cent.

Sulphur: Not more than .04 of one per cent.

Elongation (1-4 in. and under): 25 per cent in 2 in.

Elongation (1-4 in. to 7-16 in. inc.): 25 per cent in 4 in.

Elongation (7-16 in. to 1 in. inc.): 25 per cent in 8 in.

Elongation (1 in. and over): 25 per cent in 6 in.

Reduction of Area at Rupture (1-2 in. and under): Not less than 50 per cent.

Reduction of Area at Rupture (1-2 in. to 3-4 in.): Not less than 45 per cent.

Reduction of Area at Rupture (3-4 in. and over): Not less than 40 per cent.

AMERICAN BOILERMAKERS' ASSOCIATION REQUIREMENTS.

Phosphorus: Not over .04 per cent.

Sulphur: Not over .03 per cent.

Tensile Strength: 55,000 to 65,000 lb.

Elongation (3-8 in. and under): 20 per cent in 8 in.

Elongation (3-8 in. to 3-4 in.): 22 per cent in 8 in.

Elongation (3-4 in. and over): 25 per cent in 8 in.

Cold Bending.—For plates 1-2 in. thick and under, specimen must bend back on itself without fracture. For plates over 1-2 in. thick, specimen must bend 180 deg. around a mandril one and one-half times thickness of plate without fracture.

BRITISH BOARD OF TRADE REQUIREMENTS.

Tensile Strength of Plates Not Exposed to Flame: 60,480 to 71,680 lb. per square inch.

Tensile Strength of Plates Exposed to Flame: 58,240 to 67,200 lb. per square inch.

Elongation: From 18 to 25 per cent in 10 in.

STANDARD SPECIFICATIONS ADOPTED BY THE ASSOCIATION OF AMERICAN STEEL MANUFACTURERS.

Special Open-hearth Plate and Rivet Steel.

Steel shall be of four grades, as follows: *Extra Soft, Fire-box, Flange* or *Boiler*, and *Boiler Rivet Steel.*

Extra Soft, Fire-box and Boiler Rivet Steel: Maximum phosphorus, .04 per cent; maximum sulphur, .04 per cent.

Flange or Boiler Steel: Maximum phosphorus, .06 per cent; maximum sulphur, .04 per cent.

PHYSICAL PROPERTIES.

Extra Soft and Boiler Rivet Steel.

Ultimate Strength: 45,000 to 55,000 lb. per square inch.

Elastic Limit: Not less than one-half the ultimate strength.

Elongation: 28 per cent.

Cold and Quench Test: Bends 180 deg. flat on itself without fracture on outside of bent portion.

Fire-box Steel.

Ultimate Strength: 52,000 to 62,000 lb. per square inch.

Elastic Limit: Not less than one-half the ultimate strength.

Elongation: 26 per cent.

Cold and Quench Test: Bends 180 deg. flat on itself without fracture on outside of bent portion.

Flange or Boiler Steel.

Ultimate Strength: 52,000 to 62,000 lb. per square inch.

Elastic Limit: Not less than one-half the ultimate strength.

Elongation: 25 per cent.

Cold and Quench Test: Bends 180 deg. flat on itself without fracture on outside of bent portion.

(13) *Special Properties of Steel.* Mild or low carbon steel may be welded, forged, flanged, rolled and cast. It can not be tempered or hardened with a proportion of carbon lower than about 3-4 of one per cent. High carbon steel can be welded only imperfectly and if very high in carbon not at all. It can be forged with care, and cast into forms as desired. It can be tempered or hardened by heating to a full yellow and quenching in cold water or by other means, and then drawing the temper to the point desired.

Mild steel should not be worked under the hammer or flanging press at a low or "blue" heat, as such working is found in many cases to leave the metal brittle and unreliable. Steel in order to weld satisfactorily should have a low proportion of sulphur, and special care is required in the operation, because the range of temperature through which the metal is plastic and fit for welding is less than with wrought iron.

In the operation of tempering, the steel after quenching is very hard and brittle. In order to give to the metal the properties desired, the temper is drawn down by heating it up to a certain temperature, and then quenching again, or, better still, allowing it to cool gradually, provided the temperature does not rise above the limiting value suitable for the purpose desired. If the reheating is done in a bath of oil the conditions may be kept under good control and the final cooling may be slow. If the reheating is in or over a fire the control is lacking and the piece must be quenched as soon as the proper temperature is reached. This is usually determined by the color of the oxide or scale which forms on a brightened surface of the metal. The following table shows the temperatures, corresponding colors, and uses for which the various tempers are suited:

430°	Faint yellow.	Hardest and keenest cutting tools.
450°	Straw yellow.	
470°	Full yellow.	Cutting tools requiring less hardness and more toughness.
490°	Brown yellow or orange.	
510°	Purplish.	Tools for working softer materials, or those required to stand rough usage.
530°	Purple.	
550°	Light blue.	Spring temper. Used for tools requiring great elasticity or toughness, or for working very soft materials.
560°	Full blue.	
600°	Dark blue.	

(14) *Special Steels.* In the common grades of steel the valuable properties are due to the presence of carbon modified in some degree by other ingredients as already described. There are other substances which by uniting with iron in small proportions are able to give to the combination increased strength or hardness or other valuable properties. We have thus various special steels in which the properties may be due to the presence of both carbon and other ingredients, or due chiefly to special ingredients other than carbon. Of these special steels we may note the following:

Nickel steel, containing somewhere about 3 per cent of nickel and varying amounts of carbon, is found to have increased strength and toughness as compared with ordinary steel. Nickel steel is most extensively used for armor plate, though to some extent it has been employed in Government work for screw-shafts and for boiler plates. For the former purposes it has given excellent satisfaction, but for the latter use difficulty has been met with in obtaining plates free from surface defects.

Chrome steel, containing from .5 to 1.5 or 2 per cent of chromium may be made excessively hard, but it is not always reliable, and is not regarded with general favor.

Tungsten steel or *mushet steel* is a steel containing carbon and tungsten, the latter in proportions as high as 8 to 10 per cent. This steel must be forged with care and is excessively hard. The hardness is not increased by tempering, but is naturally acquired as the metal cools. Hence it is said to be self-hardening. Some specimens contain also small amounts of manganese and silver. Its chief use is for lathe and planer or other cutting and shearing tools where excessive hardness is required.

(15) *Uses of Steel in Marine Construction.* In modern practice mild or structural steel is used entirely in the construction of ships.

The same general class of material is used for all parts of boilers, though the tubes are still sometimes made of wrought iron.

Cast steel is used for various parts of engines such as pistons, crosshead blocks, columns, bed-plates, bearing pedestals and caps, propeller blades, and for many small pieces and fittings. Pistons are made almost exclusively of cast steel. For most of the other items mentioned cast iron is still used, probably to a larger extent than cast steel, especially where the castings are large and complicated in form, as with columns and bed-plates.

Forged steel is used for columns, piston-rods, connecting-rods, crank and line shafting, and for many other smaller and minor parts.

THE ART OF MAKING MECHANICAL SKETCHES—FOR MARINE ENGINEERS—VII.

BY PROF. C. W. MAC CORD.

The importance of a judicious selection and arrangement of the views has been already mentioned more than once. But we make no apology for again calling attention to it, because experience has shown that mechanical drawings can be made which are theoretically correct and accurately executed, and, in spite of all, are difficult to read and to work from.

This may be due to more than one cause: the first, as we conceive, follows from the fact that in the discussion of the theory, the construction of three views is in the majority of the illustrations desirable, if not indeed necessary. And we have known cases where the inference has been drawn, and, worse still, acted on, that three views of the whole thing must be made. That this is not so was illustrated in the sketch of the crank and crank-pin, Fig. 28,* and it is shown in a still more emphatic manner in the accompanying sketch of the connecting-rod, Fig. 29.

In this case it is quite clear that an end view of the cross head end of the rod, which is forked, would have been not only useless but obscure. Of course it might easily enough be made, but if it were introduced in a working drawing the chances are that the mechanic would think it was put there for some good reason, imagine it his duty to find out what that reason was, and waste time in the vain attempt. In like manner a top view of the crank end would be equally useless, although one of the forked end is absolutely necessary. In relation to this, one rule applies in all cases, and that is that the drawing or the sketch, as the case may be, must be such that by its aid the work-

*See February, 1899, issue of Marine Engineering, page 43.

man *can make what is required without the possibility of mistake.* This condition being satisfied, the draughtsman's work is done and his responsibility ends.

Fig. 29 ilustrates a case (of frequent occurrence) in which it is wholly unnecessary to attempt to sketch the whole object; much space is saved by breaking out the greater part of the shank of the rod, and at the same time the two ends can be drawn on a larger scale and, therefore, more clearly.

The same expedient may be, and often is, adopted in making an instrumental drawing, which may be made more complete by the addition of a drawing of the whole shank, or at least a side view of it, on a small scale. This addition would be necessary in the sketch as well were the shank made, as it often is, with a swell in the middle; but the fact that it is *not* given is a positive indication that there is in this case no swell, but that the rod tapers uniformly from its least diameter to the greatest.

Another cause of obscurity in otherwise perfect drawings is a mistaken impression that everything which is shown in one view must be shown in the others, which often leads to the introduction of a confusing multiplicity of dotted lines. But if any part is sufficiently shown in one view it is not necessary to show it in another one. For instance, the bolts of the pillow-block end in Fig. 29 are fully defined in the side view, it being understood that a square head or nut is always drawn with the flat side toward the observer, and a hexagonal one, with *one* flat side similarly placed, in *any view in which the bolt is shown "side on."* Now something in the way of an end view is necessary here, but it would display very bad judgment to make this an outside view of the whole, as is sometimes done; it is perfectly obvious that many dotted lines would be required, much to the detriment of clearness. Instead of that a view of the "butt brass" (the one next to the shank of the rod) is alone given, the rod being taken apart and everything else removed. This view is taken from the right, looking toward the left, and, supposing a film cut off just beyond the center line, the brass is shown in section, thus clearly exhibiting its conformation.

Before dismissing this sketch a little may be said in regard to the annotation. The instruction, "*Wrought Iron Polished,*" implies that the greater part of the structure is of that material and that all parts are to be polished which are not marked "*Rough,*" as for instance certain portions of the brasses. The parts *not* of wrought iron are designated by reference letters explained in the annotation as "*a, a, Composition Metal.*"

Mention may here be made of a method sometimes adopted of distinguishing different metals or materials by means of conventional variations in the style of "sectioning" or hatching of parts shown in section. Nothing of that kind, of course, is possible in making sketches; and in regard to instrumental drawings, where it is possible, it is to be noted that since there is no universal system by which the various materials can be positively recognized, nothing yet devised is a perfect substitute for reference letters with proper marginal explanations. These are neat, easily made and cannot be misinterpreted. For the benefit of those of our readers who propose to make finished drawings it may be added that all systems of "conventional section-lining" which have yet been proposed are open to the objections that they are difficult of execution, waste much valuable time, are hideous in appearance, and, well or ill done, they ruin the effect of the best executed drawing.

In the preceding article a passing allusion was made to the fact that skill in making free-hand sketches in good mechanical proportion is a qualification of special value to the designer. Indeed a fair degree of skill in this direction is absolutely essential in designing a new machine, if it be at all complicated. No matter how clear a conception has been formed as to the general arrangement of the whole and the relations of the parts, some visible record of that conception, to which reference may be made on occasion, is necessary before the designer can proceed with confidence of success in the elaboration of details, and this record is as a matter of course made in the form of a sketch.

To be sure, this first skeleton is not necessarily wholly free-hand, since certain definite dimensions are often assigned as a basis, such as the bore and stroke of a steam engine, specific movements of given pieces, which must be reduced to settled proportions, and many other conditions which may indicate within close limits some leading features of the skeleton diagram, so that instrumental construction may be absolutely necessary in preparing as one may say the foundation of the contemplated structure. But the

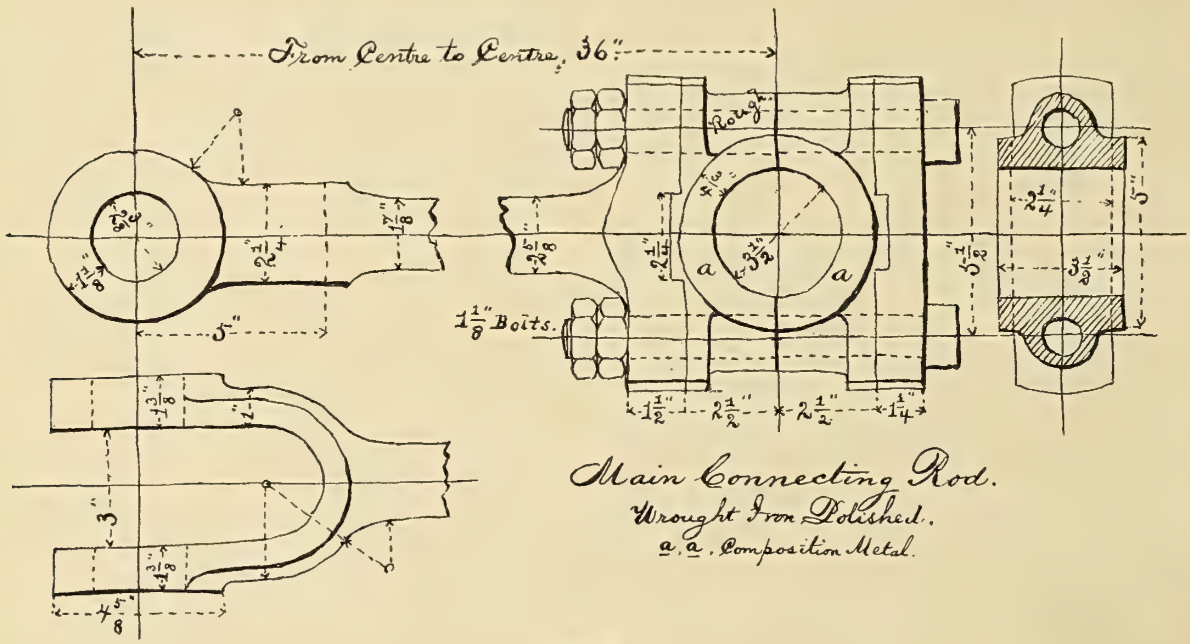


Fig. 29.

first steps in filling out the skeleton into the complete body is ordinarily dependent upon free-hand work, what may be called a sketch plan being thus produced, serving as a guide in subsequent operations, but subject to alterations as they may be suggested or perhaps required in the development of the scheme.

In simple cases it may be possible to proceed at once with the laying out of details, these being added one by one to the sketch plan as they are completed; but this is not at all a safe course in dealing with complicated mechanisms, where it is usually advisable and often imperative to make upon the sketch plan itself such representations of at least those parts which are immediate neighbors as will give reasonable assurance that no interference will occur when the details are finally worked out.

All this must obviously be done largely with the free hand, and it is equally clear that the sketch will be the better in the precise proportion in which the details as sketched resemble in form and approximate in dimensions the working drawings when eventually reduced to scale.

And again it must be recollected that the problems presented in the process of designing a machine are seldom so sharply limited as to admit of but one solution which excludes all consideration of different ones. On the contrary the desired object can, far more often that not, be accomplished in several different ways, each having advantages of its own, and a selection can be made only by comparison, for which reasonably accurate sketches are absolutely indispensable. On all accounts then it is a most desirable accomplishment to be able to sketch mechanical details in proper proportion; and in acquiring it, certain lines of practice may be suggested as likely to be of benefit to those who are industriously disposed.

First of all is to be named the making of sketches directly from the object, without *measurement*. It is better at first to begin with comparatively small objects, such as minor details, and to make the sketch of full size. In this way the relation between the drawing and the thing drawn is better fixed in mind, so that the operator becomes the more able, upon examining a full-size drawing, to form an adequate mental conception of the actual appearance of the machine itself. *After the sketch is finished* both the object and the sketch should be measured, in order to ascertain the closeness of the approximation. If the object be large, the sketch may be made on a reduced scale, and when completed the test is made as before by measurement; a leading part, as for instance the diameter of a journal in the sketch, being compared with it actual size, gives the scale of reduction, and all other parts should be found reduced in the same proportion.

Next to this may be named the making of free-hand copies of working drawings. This is obviously beneficial, since in designing the very object is to make sketches which shall resemble working drawings as closely as possible. Of course, in this kind of practice the proportions of the original are to be preserved, but the scale may be varied with advantageous results.

And still again the making of sketches from memory will be found of the greatest benefit, and that no less for the professional than for the tyro. In doing this it is necessary to form a clear mental conception of the work in hand, very closely akin to that which a designer must have. In a word, the operator to be successful must see not only the lines he is making with his physical eye, but also (with his mental eye) the object itself, and he should see the one as clearly as the other. Sketches may be made in this way, either from the recollection of an object examined and studied or from that of a working scale drawing, and when practicable the accuracy of the sketch should be tested by subsequent comparison with the original. This desired power to sketch in proportion is to some extent a natural gift, but by faithful work along these lines it may be cultivated and greatly strengthened.

ENGINEERS' DICTIONARY—XVII.

Expansion Joint.—A form of joint in a steam pipe which will allow of expansion or contraction lengthwise without buckling or straining the pipe. The common form of expansion joint is shown in Fig. 70, and consists of a recessed portion on one part of the pipe into which the other part fits as shown. The space left between the two thus forms a stuffing box into which packing is compressed by means of the gland as shown. The two parts of the pipe are thus free to slide a little way, one relative to the other, while the joint is kept tight by means of the stuffing box and gland in the usual way. As may be seen, the

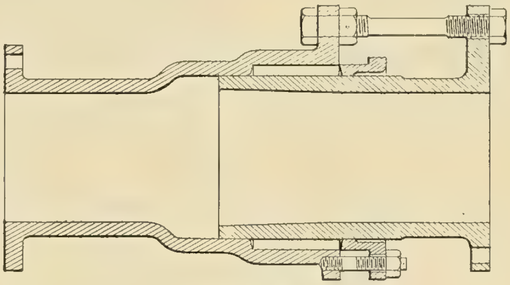


FIG. 70.

steam pressure within the pipe, especially if it contains a bend, will tend to force the two portions of the joint apart, and thus open the pipe at this point. To guard against this, struts or safety stays should be fitted. In the figure one of a pair of such stays is shown by the long bolt on the top. In special and more complicated forms, known as balanced or equilibrium expansion joints, these forces are more or less completely balanced at the joint itself.

Feathering Propeller.—A form of screw propeller in which the blades may be turned about a radial axis, thus changing their pitch, or even turned so far that their direction of inclination relative to the axis is reversed and the propeller is changed from right-hand to left-hand, or *vice versa.* With such a propeller backing is effected by simply allowing the engine to run constantly in one direction and reversing the blades as may be desired. There are various forms of mechanism used for controlling and effecting the reversal, but they fall usually under the two classes, of control by gearing, or by rods and eccentric pins. The hubs of such propellers having to contain a certain part of the reversing mechanism are usually quite large, though not perhaps much larger than those of propellers with separate blades. Such propellers have met with some favor for use on small craft fitted with gas and oil engines, most of which have necessarily to run continuously in one direction. Where a screw propeller is used as an adjunct to sails, it presents a considerable resistance when not in use by being dragged, turning, through the water. In such case a feathering propeller by allowing the blades to be placed fore and aft will present a less resistance than one of the usual form.

Feed Pipe.—A pipe serving to conduct the feed water from the feed pump to the boiler.

Feed Check.—See *Check Valve.*

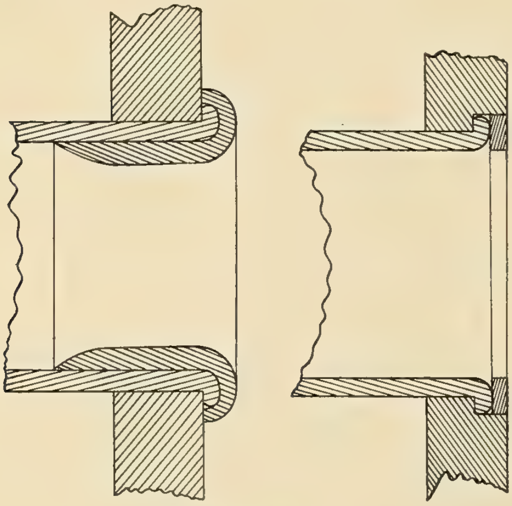
Feed Heater.—A device for specially heating the feed water before its entry into the boiler. Feed heaters fall into two chief classes according as steam or waste furnace gas is made the agent for effecting the heating. If steam is used it may come from the boiler direct, or the exhaust steam from some of the receivers or from non-condensing auxiliaries such as pumps, blowers, etc., may be employed. Again, the steam used to effect the heating may be either mingled with the feed water direct by some suitable form of spraying device, or it may pass on one side of a series of thin copper or brass tubes while the feed water passes on the other, thus effecting the heating by transfer through the metal of the tubes. At the same time the water formed by condensation on the steam side of the heater is collected, trapped out, and turned into the feed-water system, so that no fresh water may be lost.

When the waste furnace gases are used, some form of tubular heater must necessarily be used. The nests or coils of pipe are located in the uptakes or base of the stack, and the water is passed through them or on the inside, while the waste gases pass around them or on the outside. Such forms of feed heaters are coming to be considered as quite an important part of the water-tube boiler. In such case the whole combination may really be considered as a boiler in two stages. The first consists of the feed-water heater in which the water is heated up to nearly or quite the boiling point, but in which it is not desired to actually generate steam. In the second part, or boiler proper, the water thus heated is taken and the operation of conversion into steam is completed. In some cases both forms of feed-water heater are used.

If the original temperature of the feed water is about 100 deg. F., its temperature after passing through the ordinary forms of heaters may be from 150 deg. to 200 deg. With special forms of heater, however, the temperature may be carried quite up to the temperature of boiling.

Felt or Felting.—Some form of fibrous or semi-fibrous fireproof material, made in sheets and used for wrapping steam pipes and boilers, in order to prevent the loss of heat. Fireproof felt is made of a great variety of substances of mineral or of mineral and animal source. A good felt for the engineer's purpose should be fireproof, not too heavy, readily fitted in place about pipes and steam fittings, and should not lose its properties by the long continued application of heat.

Ferrule.—A cast-iron fitting placed in the combustion chamber ends of the tubes in fire-tube boilers. When such boilers are severely forced, especially if the proportion of heating surface is small, the effect is especially severe at the tube ends, where the hot gas enters, resulting in the production of leaks and a



FIGS. 71 and 72.

kind of scoring or wearing away of the metal about the ends. This condition is greatly relieved by the use of cast-iron ferrules, fitted as described above and as illustrated in Figs. 71 and 72.

Fire Brick.—A kind of brick made of clay containing but a small amount of readily fusible substance. It is thus able to stand without injury very great heat and is therefore used for building or lining bridge walls and baffle plates, or other parts of boiler furnaces where metal cannot be used to good advantage.

QUERIES AND ANSWERS.

(Communications intended for this department will not receive attention unless accompanied by the full name and address of the sender, which will be considered confidential.)

The communications of C. J. Enger and of G. V., in regard to matters referred to in this department, are acknowledged. For want of space they are held over for future publication.—EDITOR.

Q.—Having an interest in a small steamer, fitted with compound engines 17 in. and 28 in. by 27 in., Scotch boiler, two furnaces, 32 sq. ft. grate surface, boiler fed direct by pump worked by main engine, no grease filter and feed tank fitted, the information I wish is as follows: Would you restrict all internal lubrication, considering sufficient that entering from valve and piston rod lubrication? If so, granting them in fair condition, how frequently in intervals of time should they be slushed with oil? With an occasional use of the surface blow, say a little every hour, do you think the boiler could be kept free from injury? Would you consider the use of soda the better method? If so, about what quantity and how often would it be necessary to introduce it? Need there be any apprehension of dangerous deposits on fire surfaces from oil? Should I wait until litmus paper test showed water becoming acid, then introduce soda sufficient to neutralize? Would this method be apt to cause boiler to foam? R.

A.—It is impossible to give detailed directions at long range for the oiling of an engine. In general, more oil is used than is necessary, but in restricting the quantity the engineer must be guided wholly by the circumstances of the case. The boiler can doubtless be kept reasonably free from oil by an occasional use of the surface blow as you suggest. You will not forget, however, that this means a waste of heat and that in time you will blow away the cost of an oil filter. With regard to the use of soda, this should not be necessary unless the water is distinctly acid, and such a condition should not result from the presence of pure mineral oil alone. The presence of acid in the boiler means usually either an impure oil or the presence of organic or sewage matter, or a decomposition of the salt in sea water, due to chemical reactions with the other substances present, and the formation of hydrochloric acid. In any case the litmus paper test may be recommended as a guide for the amount of soda and frequency of use. Instead of the use of soda to counteract the acidity of the water, the use of zinc slabs hung in the boiler is rather to be recommended. These are attacked by the acid as formed, which is thus neutralized without special attention other than the renewal of the slabs as may be necessary.

If the surface blow is properly used there need be little fear of dangerous deposits on the surfaces of the boiler within a reasonable time, though of course it is by all means better to keep the oil out of the boiler by reducing the amount used and by fitting a good oil filter. In any event, however, the boiler should be opened and examined at frequent intervals, in order to make sure that everything is in good condition.

Foaming is often due to very obscure causes. The cautious use of soda should not in itself produce this condition. As stated here, however, zinc slabs rather than soda are to be preferred for controlling the acidity of the water, and long experience shows that they may be used freely without danger of causing foaming.

Q.—How are marine engines lined up with main shaft so as to have the plane of revolution of crank at right angles to center line of main shaft, and yet get piston, crosshead, and air, force and circulator pumps in line (when these latter are connected to main crosshead)? Also how is the center line of main shaft obtained in a ship, the stuffing box hole of which is in the ship? Is the line of the engine laid out with a transit or located from the sides of the ship? J. A. P.

A.—Every first-class shipbuilding concern has in its possession an accurate table of figures showing the amount of sag in a fine steel wire of a certain size and stretched to a certain tension, and for certain lengths of the same. In lining up shafting and locating the centers of bearings in a new job, this wire is stretched. It is fastened at one end and passes over a small pulley at the other end, with a certain amount of weight attached so that the tension is constant. In lining up an engine so that the plane of revolution of the crank is parallel to the center line of the cylinder, as well as the motion of the piston and crosshead, the accuracy attained simply depends upon the care with which the parts are machined in the shops. The gaps in the bed plates that receive the main bearing boxes are planed out so that they are all in line. If the bed plate is in one piece they are all planed in one cut, and if the bed plate is in sections, the flanges of the section are planed perpendicular to the bearings, and are then bolted together so that the gaps are in line, and this can easily be done by trying the sides of the gaps with straightedges. The places where the feet of the columns rest on the bed plate are planed at the same time. If the feet of the columns and also of the cylinders are planed true the cylinder will come in place accurately, and if a wire is stretched through the center of the cylinder and set perpendicular to the gaps in the bed plate at a point representing the center of crank pin box, the bore of the cylinder can be located.

In setting up the attached feed pumps and circulating and bilge pumps many different devices can be used, depending on their kind and location. If they are seated on the main engine bed plate, their seating will probably be planed at the same time that the main bearing gaps were planed, and if the pump bases were faced at the same time that they were bored they will set perpendicular to the bed plate and consequently parallel with the center of cylinder, and the fore and aft position can be located by means of a steel square from the gaps in the bed plate and the steel wire.

The center of the line shaft is located by means of the wire as first described. If the center of the stern tube at the stern post is located, the wire is fastened there and run forward and set central by means of a line run down in the middle, between the frames, to the keel. In twin screw ships the position of the centers at the after bearings is determined by measuring from the center of the stern post out to each, and also squaring off the stern post so that the two centers are at the same level above the keel. On the stocks the latter operation can be done with a level. The two lines are set equidistant from the center of the keel at the forward end. Many other lines and measurements are run to check these, as there may be slight variations in the structure. In most cases the shafts are not longitudinal to the keel, but incline downward on going forward, so that the engine sets low in the vessel and the shafts at the stern are high enough to swing the proper size of propellor above the level of the keel. In large twin screw jobs the shafts incline forward the same as just explained, and also toward the center, so that the engines can be close to each other and allow the propellers to swing without overlapping. Such positions require considerable care to get them accurately located. We know of no work treating of the subject.

Q.—Please publish a rule by which I can find the pressure on a thrust block of engines of a known horse power. Also, is there any chemical by which minerals can be separated from the vegetables in oil? Will the acid separate or saponify the vegetable matter? Also please state what the pay will be of a "warrant machinist" in the Navy under the new law, and where the examinations take place? TEXAS.

A.—To find the pressure on a thrust block the following rule may be employed:

Rule: Multiply the I. H. P. by 22,000 and divide by 101.3 times the speed of the ship in knots. The result is the thrust in pounds.

Thus, if I. H. P. = 1,000 and speed = 10 knots, then:

Thrust in pounds = (22,000 × 1,000) ÷ (101.3 × 10)
= 21,710 lb.
= 9.69 tons.

Regarding the oil, if you wish to know a way for separating vegetable oil from mineral oil, the method most suitable for ready use is to boil up the oil with caustic soda or potash—the caustic lye used for cleaning will answer. This will saponify the vegetable oil and leave the mineral oil behind, so that it may be readily separated. Diluted acid will also saponify vegetable oil, but its use is attended with more practical difficulties than that of caustic soda or potash.

Neither of these methods would answer, of course, if it were desired to save the vegetable oil. In such case the resources of a chemical laboratory would have to be called into service.

The pay of a "warrant machinist" will be $100 per month at the start, together with a ration of 30 cents per day, making an equivalent of about $109 per month. With length of service the amount rises from $100 per month at the start to $150 per month after 12 years' service. So far as known, the dates and locations of the examinations have not yet been announced.

Q.—Please explain the method of lining the crank shaft of a small vertical cylinder center-crank marine engine, with 9 in. by 10 in. cylinder. Also the way to tell when the connecting rod is hung fair. NOVA SCOTIA.

A.—In constructing the type of engine you mention it is usual to plane the bottoms of the gaps in the bed plate that hold the main bearing boxes, so that they are true with the center line of the cylinder. It is consequently a simple matter to adjust the boxes so that they will have the same thicknesses at the bottom, or that the distance from the center of the shaft to the bottom of the gap shall be the same on both sides of the crank. In large jobs the tops of the gaps are also planed true and when the engine is building a gauge is made consisting of a steel straight edge with a tooth in the middle. By removing the top bearing and laying the straight edge across the gap the tooth should just touch the shaft. By means of such a gauge the bearing can be lined up to its original position at any time if it is worn down. If you doubt the accuracy of the boxes of your engine, then you will have to remove the crank shaft, top cover, piston and rods, and stretch a wire through the cylinder, being careful to get it central by measuring from such parts of the cylinder as are not worn, as, for instance, the counterbore at the top or the stuffing box below. See that the wire is taut, and then you can work from this as a center line,using a steel square or straight edge. To find out if the connecting rod is hung fair, disconect the crank pin box or big end, support the crosshead so that the foot of the connecting rod may be swung from side to side, and then caliper the distance between the foot of the rod and the face of the crank cheeks. Turn the crank shaft in different positions and caliper as described, then if the measurements agree for all positions the connecting rod is hung fair.

Q.—Please give me a formula for finding the diameter of boat davits when the weight of boat and the shape of the davits are given. The davits I want to figure on are for a boat 5,000 lb. weight. S.

A.—Where the overhang of the davit is to be several times the diameter, the following formula may be used:

$$d = 2.2\sqrt[3]{\frac{AW}{\quad}}$$

a = overhang of davit.
w = load for one davit.
p = safe stress per square inch, which may be taken about 7,000 for iron and 10,000 for steel.

According to this formula, one of a pair of davits for a 5,000 lb. boat, a being from 24 to 30 in., would have a diameter of from 4 to 4 3-4 in., according to the material used.

Q.—Please publish a description of different methods of riveting and their relative efficiency. Also the U. S. rule for calculating the pressure on bumped heads of boilers. J. M.

A.—There will soon appear in the educational department of MARINE ENGINEERING full descriptions and rules for the various forms of riveted joints. See also pages 27 to 32 of this issue.

The U. S. rule for bumped heads is as follows:

"*Pressure Allowed on Bumped Heads.*—Multiply the thickness of the plate by one-sixth of the tensile strength and divide by one-half of the radius to which head is bumped, which will give the pressure per square inch of steam allowed."

Q.—Can you give me a value of π beyond the customary five places of decimals? To what extent has it been worked out accurately? LOG.

A.—The value of π (or ratio of diameter to circumference) is given to thirty-two places by Molesworth as:

π = 3.14159265358979323846264338327950 +

If we are not mistaken an English mathematician worked this out to 600-odd places about thirty years ago, and the story is that one of the most eminent mathematicians of that time started in to check the figures, but after finding no inaccuracy as far as 400 places he got discouraged and quit.

Vol. VI of the Transactions of the Society of Naval Architects and Marine Engineers has been issued from the office of the Society, 12 West Thirty-first street, New York. This contains the full text of the papers read before the 1898 meeting of the Society, held last November, together with a complete report of the discussions which took place at the meeting, and those which were in the shape of written communications. There is an especial interest in this volume in that it gives an account of the meeting held during the war year, and which consequently was the occasion for much statement of fact and comment in connection with the operations of our Navy. Aside from the value of the text, the volume would be indispensable for the sake of the plates, containing working drawings and valuable photographs which occupy fully one-half of the volume. Those contributed by Chief Constructor Philip Hichborn, U. S. N., covering a great range of vessels from a practice sailing ship through a great variety of competitive designs for torpedo boats and destroyers to first-class battleships, are of the greatest practical and scientific value, a splendid contribution to the literature on these subjects. Another invaluable series of drawings is that which accompanies the paper on small boats, by Arthur B. Cassidy, U. S. N. The fine professional spirit which gives out these experiences for the benefit of all engaged in such work is a feature which fitly indicates the aims of the Society. This volume is of the very highest interest and value and is indispensable to the practising naval architect and engineer. It is sold at the low subscription price of $10.00.

TRADE PUBLICATIONS.

The Boston Belting Co., 256 Devonshire street, Boston, Mass., is sending out to all its friends a private postal card ilustrating the fact that antiquated outfits in rubber goods must go. The picture represents a small child driving a hobo before him with a stream of water from hose.

The 1899 catalogue of the Marine Iron Works, Station A, Chicago, Ill., is just received. It is very fully ilustrated, containing pictures of the different types of simple engines manufactured by this company, the illustrations being full page in size, so as to give much detail. Equal information is given regarding compounds, both steeple and fore and aft, together with a great deal of other information regarding special features of steamboats and vessels. A fine picture is shown of a triple cylinder and also of a stern paddle wheel engine of modern type. There is also much information regarding different types of boilers, both vertical, horizontal, Scotch, etc., which this company makes, and a full line of propeller wheels and all other kinds of steamboat machinery. Any of our readers interested in steamers of any kind, from a small launch to large river boats or fine steam yachts, will want a copy of this catalogue for permanent reference.

"Learn to Draw" and "Can You Read a Drawing?" are the titles to two folders issued by the International Correspondence Schools, Box 1111, Scranton, Pa. The subject of drawing is one which will interest our readers, and many will undoubtedly want to send for copies of these pamphlets.

A catalogue regarding the projector search lights manufactured by Thomas P. Benton & Son, La Crosse, Wis., is now ready for distribution. The catalogue contains a detailed description of the lights, giving the manner of their construction and the various kinds, showing their adaptability to vessels of any type, from a small river boat to a large steamer.

Sturtevant electric fans are illustrated fully in a four page folder, Bulletin M, issued for the month of April. The illustrations are of large size and are exceptionally fine, bringing out all the details of the motors used. These electric fans are made from one-sixth horse power up to twenty horse power and are particularly adapted to steamship work.

Seamless cold drawn steel boiler tubes as manufactured by the Shelby Tube Co. are fully described in an eighteen page catalogue. Considering the steady increase of high pressures and the importance of seamless tubing, all of our readers will want a copy of this catalogue, which is not an ordinary trade affair, but written in such a way as to give much valuable information. Considerable attention is given to the manner in which tubes are manufactured, and much other interesting and valuable information is given. Seamless tubing, as the catalogue states, has met the approval of and is preferred to all others by the British Admiralty, while the United States Navy has nearly all of the torpedo-boat boilers fitted with seamless cold drawn steel tubing, and the specifications have been revised so as to admit of its use in boilers of the Scotch type. A considerable extract is given on page 12 of the catalogue of the specifications and inspection of such tubing for use in the Navy. Copies can be had by applying to the Shelby Tube Co., Cleveland, Ohio.

BUSINESS NOTES.

Garlock Packing.—The Garlock Packing Co. calls attention to the packing of its manufacture, which it claims to be of only one grade and that the best. This company makes packing for any use where soft packing can be applied, and makes a specialty of supplying packing for special uses. The head office of the company is in Palmyra, N. Y., with sales offices in all the leading cities.

Brass and Copper Goods.—The U. T. Hungerford Brass & Copper Co., 121 Worth street, New York, has recently added a large warehouse and shipping department, and is now in shape to fill orders promptly for seamless brass and copper tubing, brazed tubing, sheet and bolt copper, rivets, tacks and nails, and a full line of other articles made of either of these metals.

THE JOSEPH DIXON CO.—The annual meeting of the stockholders of the Joseph Dixon Crucible Co., Jersey City, N. J., was held last month and all the officers were re-elected. The report to the stockholders shows one of the most satisfactory years of business in the history of the company, particularly in the demand for graphite paint for protection against the elements.

TIN PLATE.—In the many uses for which tin plate is necessary the matter of quality plays an important part, especially where there is much exposure to the elements. Special attention is given to this subject by Merchant & Co., 517 Arch street, Philadelphia, Pa., who claim to carry only those plates which are heavily coated and which are of a quality to withstand the greatest amount of exposure. This company has made a specialty of these plates for a great many years and has recently filled an order for several carloads for shipment to the southern states.

DRAUGHTSMEN'S SUPPLIES.—Our readers will be interested in the advertisement of the Keuffel & Esser Co., 127 Fulton street, New York, which furnishes everything required for drawing and measuring. This company is one of the recognized leaders in the country in this line of business and the standard of quality of its goods is well known. Practically everything sold by this company is either manufactured in its own shops or absolutely controlled by them, and quality is guaranteed. A very complete and thoroughly illustrated catalogue of over 400 pages is sent free of charge to all inquirers who hold positions in which drawing or measuring instruments are used.

FIRE PROTECTION.—A new form of fire extinguisher has been perfected by the Deming Co., of Salem, Ohio, for use in offices, shops, warehouses, and on yachts or steamboats. It consists of a readily portable bucket with pump, hose and nozzle attached. The nozzle is arranged so that it will give a spray or solid stream, and in the former case it is useful for cleaning windows and woodwork of all sorts. When the bucket is filled the pump is ready for instant use, and an advantage is that its condition can be seen at a glance and the apparatus thus kept constantly filled and ready for any emergency.

PNEUMATIC TOOL INTERESTS CONSOLIDATED.—One of the most important and interesting events in pneumatic tool matters of late was the purchase on April 6, by the National Pneumatic Tool Company, of Philadelphia, Pa., from the American Pneumatic Tool Company, of New York, of the sole and exclusive right to manufacture pneumatic chipping, caulking and riveting hammers under all patents owned by the latter company, which was the first concern to place this class of tool on the market. The American Pneumatic Tool Company has brought a number of suits for infringement of its patents on both valve and valveless hammers, and the United States Court of Appeals for New York has decided in its favor. It is said to be the intention of the company to bring additional suits for infringement against users of hammers not manufactured by the National Pneumatic Tool Company.

Fine New York Store.—Owing to the great increase to its eastern business the Q. & C. Co. has moved into a large store at 106 Liberty street, New York, giving much better facilities than have heretofore been afforded for handling pneumatic tools, metal saws and other tools and machines which are specialties of this company.

Baldt Anchors.—We are informed by the Baldt Anchor Co., Chester, Pa., that with the large facilities at hand for manufacturing it now carries a large number of anchors in stock and can fill orders without any delay.

Decision Regarding Magnetic Blow-out. — The Thomson-Houston Electric Co. endeavored to enjoin the Bullock Electric Co. from using a magnetic blowout with controllers, claiming that the Bullock company infringed Letters Patent Nos. 283,167 and 401,085; but Judge E. H. Lacombe, on March 6, after hearing the arguments in the case, refused to grant this injunction.

FIREPROOF WOOD.—The American Wood Fireproofing Co., 11 Broadway, New York, is building large works at Newark, N. J., and will soon be in position to fill all kinds of orders for fireproofing timber and lumber for all purposes used in marine work. This company will either do the fireproofing itself or sell the rights for others to do it under royalty.

HOWDEN HOT DRAFT.—The two freight steamers which the Detroit Dry Dock Co. is about to build will be duplicates, 440 ft. over all. Each vessel will have two Scotch boilers. These two steamers, as well as the package freighter building at the yard of the Union Dry Dock Co., Buffalo, for the Western Transit Co., will be fitted with the Howden system of hot draft.

BROWN HOISTS.—The Brown Hoisting and Conveying Machine Co., Cleveland, O., has been awarded a contract from the Navy Department for coal-handling machinery for the coaling station at Mare Island Navy Yard, California, which is the sixth coaling station for the United States Navy to be equipped with machinery of this company's manufacture, and constitutes all the stations so far awarded. The company has also secured the contract for a 100-ton steel floating crane, weighing over 1,000 tons, for the New York Navy Yard.

INCREASED FACILITIES FOR MACHINE BUILDING.—Owing to the great demand for tools for shipyards, boiler shops, etc., the Hilles & Jones Co., Wilmington, Del., has begun work on a new steel frame addition to its plant, 80 by 150 ft. This shop will be fitted up in the most modern style.

SPECIAL NOTICES.

Announcements under this heading will be inserted at the uniform rate of thirty-three-and-a-third cents a line. Lines average ten words each.

FOR SALE.

Two new Scotch Boilers 12 ft. 6″ diameter, 12 ft. long, with 3-40″ corrugated furnaces, built under Marine Inspection Laws for 130 lbs. pressure. Specifications and blue prints furnished on application.
CAMPBELL & ZELL COMPANY,
Manfrs. ZELL IMPROVED WATER TUBE BOILER, Balto., Md.

Five-horse Water Tube Boiler, my patent, for sale. Suitable for inland waters only, all steel plate and tubes, no bricks or castings. 175 pound steam pressure carried. Weight only 450 lbs. for 35 sq. ft. h-s. Will drive 4″ x 4″ simple engine 450 revs. per minute. Stands in 30 inches square. Entirely new.
EGBERT P. WATSON, Elizabeth, N. J.

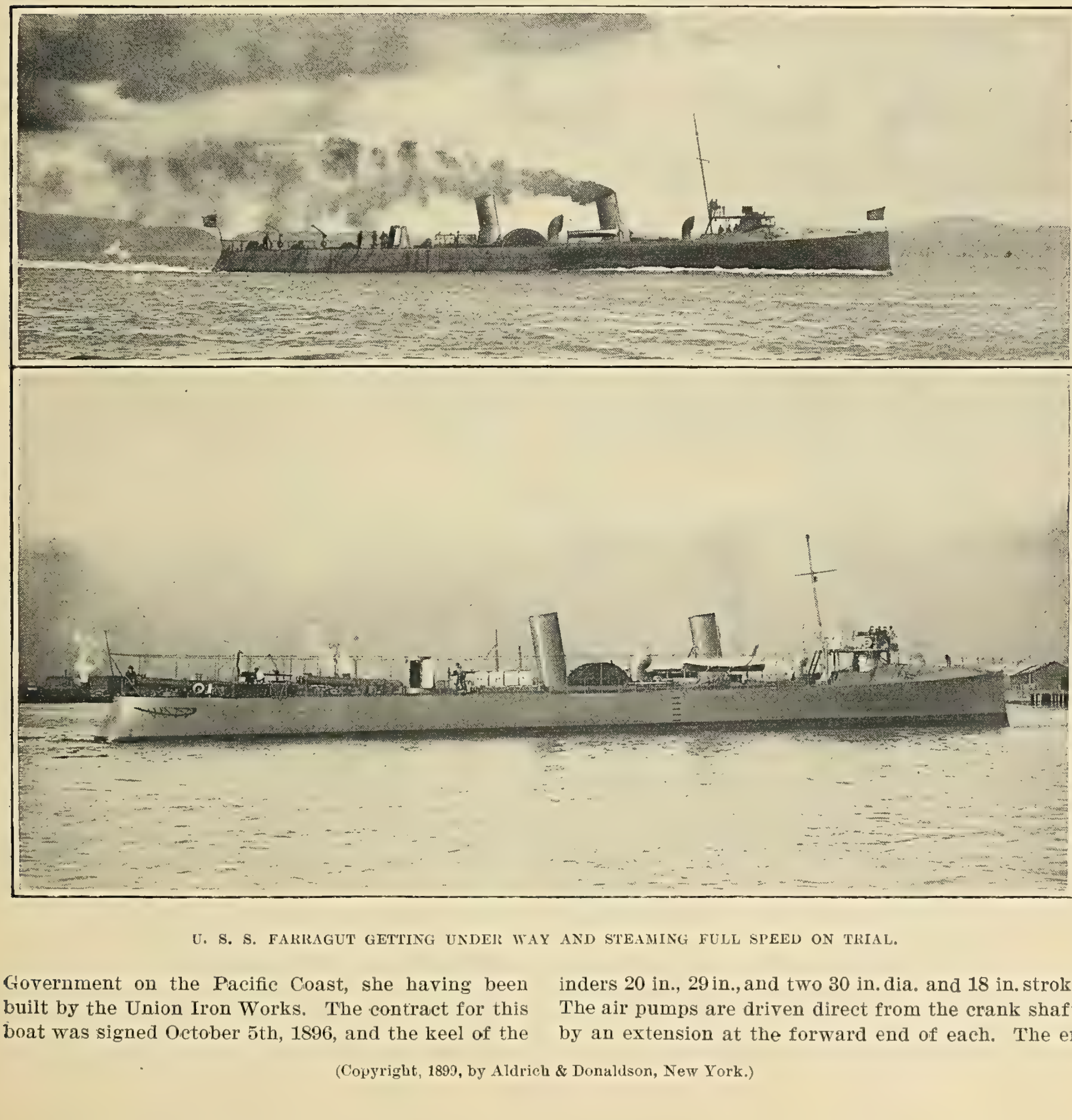
MARINE ENGINEERING.

Vol. 3. NEW YORK, JUNE, 1899. No. 6.

TORPEDO-BOAT DESTROYER FARRAGUT— FASTEST VESSEL IN THE NAVY.

Our frontispiece shows U. S. S. *Farragut*, the first American torpedo-boat destroyer, complete, equipped and ready for sea. This fine boat, which is the fastest in our Navy, was recently tried and accepted by the Government on the Pacific Coast, she having been built by the Union Iron Works. The contract for this boat was signed October 5th, 1896, and the keel of the vessel was laid July 26th, 1897. She was launched July 16th, 1898, and delivered to the Government December 31st last. Her dimensions are: Length, 214 ft. over all; beam, 20 ft.; draught, 5 ft. 7 in.; and trial displacement, 240 tons.

She is fitted with twin screw engines of the four cylinder, four crank, triple expansion type, with cylinders 20 in., 29 in., and two 30 in. dia. and 18 in. stroke. The air pumps are driven direct from the crank shafts by an extension at the forward end of each. The en-



U. S. S. FARRAGUT GETTING UNDER WAY AND STEAMING FULL SPEED ON TRIAL.

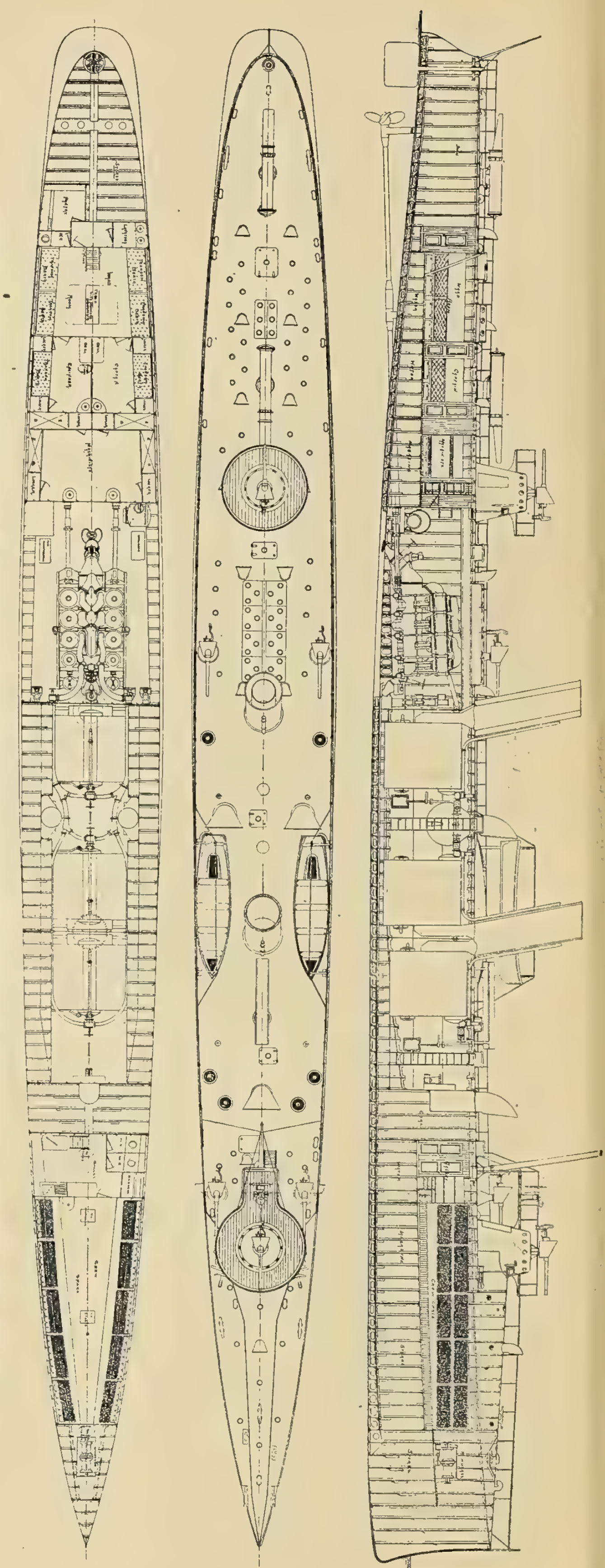
gines are of course designed with a view to getting the maximum power on the minimum weight. Hollow forgings are extensively used, including the crank shafts, each of which is in one piece with the eccentrics forged on. Very complete arrangements for oiling are provided, including centrifugal oilers for the crank pins, and large tubes down the sides of the connecting rods. The main condenser has a copper shell and is placed between the engines with scoops at both ends connected with openings in the bottom, through which the circulating water is forced by the motion of the vessel when steaming. A small circulating pump in the form of a two-bladed propeller is placed in the after scoop to start the circulation when the destroyer is starting out or lying at anchor. The boilers are three in number, of the Thornycroft type, each rated at 2,000 horse power with 240 pounds pressure. The *Farragut* also carries a distilling plant in the engine room.

The propellers are three-bladed, of solid bronze, and are carried by forged steel struts far below the keel line, the vessel being cut away tremendously aft, as shown in the outline drawings. They are 6 ft. 9 in. dia. and 8 ft. 9 in. pitch, and they turn up 420 revolutions when the boat is going full speed.

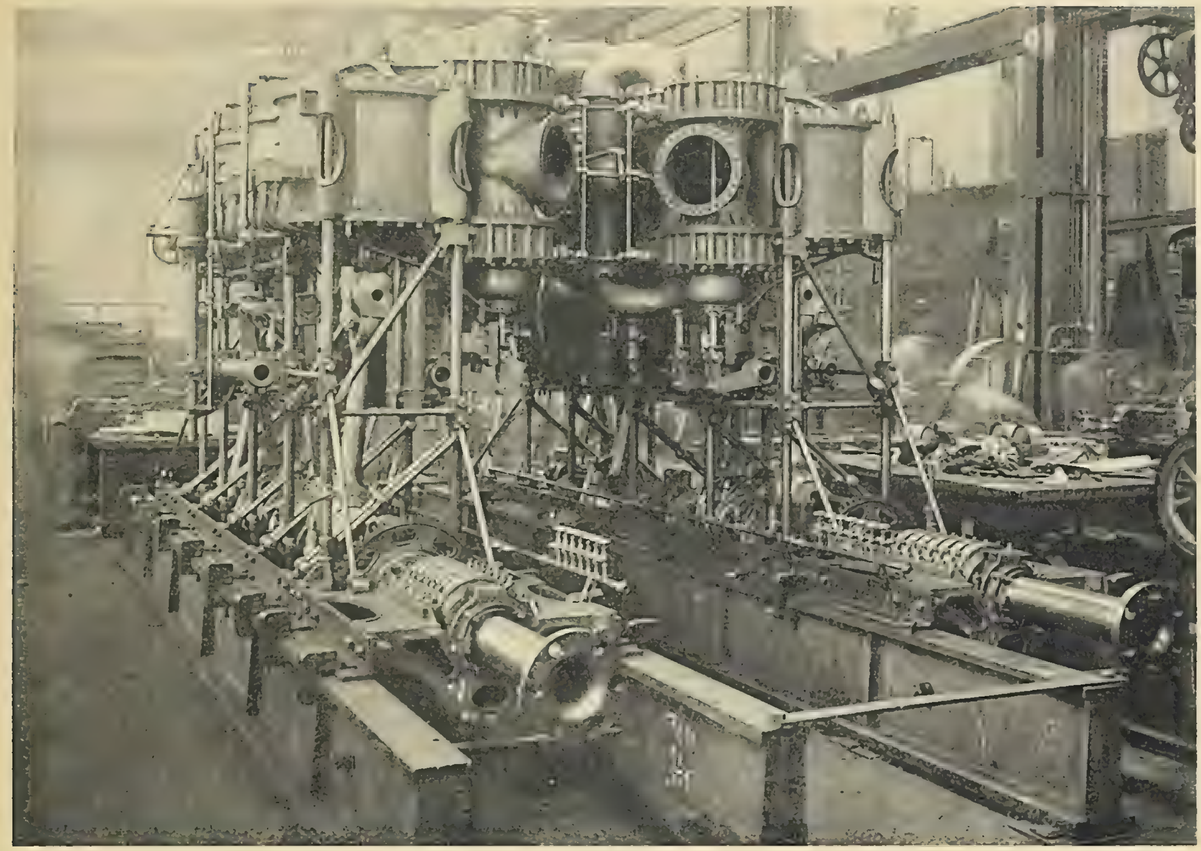
In the shape of armament she is fitted with three 6-pound rapid-fire guns, two 15 in. torpedo tubes. There is a small conning tower forward and another aft. Six torpedoes are carried stowed away forward under the turtle back.

On trial the *Farragut* showed an average rate of speed of 30.6 knots. The contract price for the hull and machinery was $227,500.

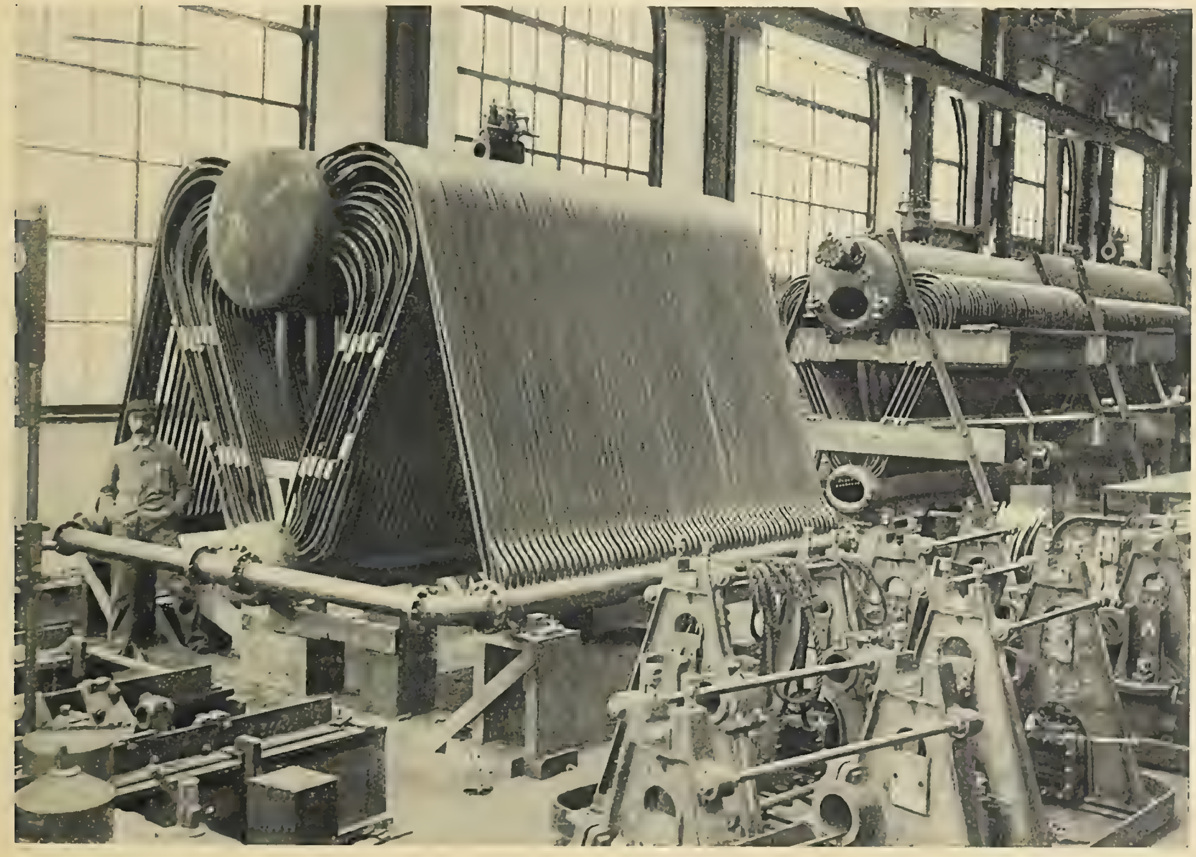
Published designs of the new royal yacht *Victoria and Albert* for Queen Victoria show an antiquated looking vessel, following very closely in general appearance the present side wheel vessel of the same name. The new vessel was launched at Pembroke Dock Yard, May 9, by the Duchess of York. She was designed by Sir William White, Chief Constructor of the British Navy, with the view of being used exclusively as a yacht; so that the vessel will not be a combination of warship and pleasure craft, as is the case with yachts of other monarchs. Considered therefore as a yacht pure and simple she is the largest vessel of this type afloat. Her dimensions are: Length, 420 ft.; between perpendiculars, 380 ft.; beam, 50 ft., and displacement 4,700 tons on 18 ft. draught of water. It was undoubtedly the wish of her royal owner that the new vessel should be designed so as to closely resemble the present *Victoria and Albert*, for in other respects the new vessel is strictly up-to-date. She will be fitted with Belleville water-tube boilers, and two sets of four-cylinder, triple-expansion engines of 11,000 collective horse power, driving twin screws. Her sea speed will be about 17 knots, but she will be capable of spurts of 20 knots. She will be sheathed and coppered, but will carry neither armor nor armament, except possibly a couple of small guns for saluting purposes. She will have high sides with large square ports running her entire length fore and aft; a clipper bow, and overhung stern, and two smoke pipes with bellmouth tops.



INBOARD PROFILE AND DECK PLANS OF THE TORPEDO-BOAT DESTROYER FARRAGUT BUILT AND ENGINED BY THE UNION IRON WORKS.



TWIN-SCREW ENGINES OF THE TORPEDO BOAT DESTROYER FARRAGUT—AFTER ENDS.



THORNYCROFT BOILERS UNDER CONSTRUCTION FOR U. S. S FARRAGUT.

SHIPBUILDING AND SHIPPING CONDITIONS OF THE UNITED STATES.—PAST, PRESENT AND FUTURE.

BY GEO. R. M'DERMOTT N.A.

From time to time the writer's opinions have been sought as to the prospects of the shipbuilding and shipping interests generally of the United States. In view of recent events connected with our late conflict with Spain, resulting in the acquisition of new territories, the development of whose resources render necessary large additions to our mercantile marine, the presentment of a few facts connected with the shipbuilding and shipping affairs of the country may prove of interest and possibly serve a useful purpose in determining capitalists and others to lend their aid toward the resuscitation and upbuilding of a mercantile marine, too long neglected, that was once the nation's pride.

Before investing money in any industry the capitalist is naturally anxious to obtain the fullest information regarding the conditions which affect that particular industry, the chief consideration being as to whether the present is the most favorable time for investment.

In shipbuilding, as in other established branches of trade and commerce, an intelligent study of the progress of the industry in the past—noting at the same time the various causes for the rise and fall in the general tendency towards full development—is the surest guide to the financier in determining the soundness and probable fate of any scheme which may be placed before him. In investigations of this kind it is desirable to extend inquiries as far back as possible, so as to obtain correct ideas of the general trend of progress as apart from the periodic fluctuations which occur at almost regular intervals in all industries, and, owing to the vicissitudes through which American shipping interests have passed, such a mode of procedure is of paramount importance.

Shipbuilding and shipowning interests are interdependent, and, although we are, here, primarily interested in the former, our investigations must extend to both fields, as the fate of one depends upon the condition of the other. Preceding, however, to our inquiries: An exposition of the facts is shown geographically in the accompanying diagrams, which have been prepared from various governmental and other reliable statistics, showing in concise form the history of American Shipping. Diagram A shows the tonnage of American shipping engaged in foreign trade during the period 1797-1898. From this we learn that in 1797 about 600,000 tons were engaged; this increased year by year up to 1810, when 981,000 were so employed. About this time, however, strained relations with Britain—culminating in the year 1812—had the effect of reducing slightly the amount of our foreign trade, dropping, as shown by average curve, to between 600,000 and 700,000 tons; this average being maintained generally until about 1832, when we find an upward tendency at an annually increasing rate to 1861, when it amounted to 2 1-2 million tons. This rapid rise was probably due, to a large extent, to the fact that during this period Europe was engaged in almost continual warfare, one country with another. In 1861, however, came the civil war, and the wealth and spirit of the country and its patriotic sons were all centered in that unfortunate episode in the nation's life. Privateers, fitted out by Southerners, tacitly supported by the British, harassed and crippled our Merchant Marine to such an extent that those persons engaged in shipping had neither the heart nor the means to continue, and selling out became general. Although the civil war was the pri-

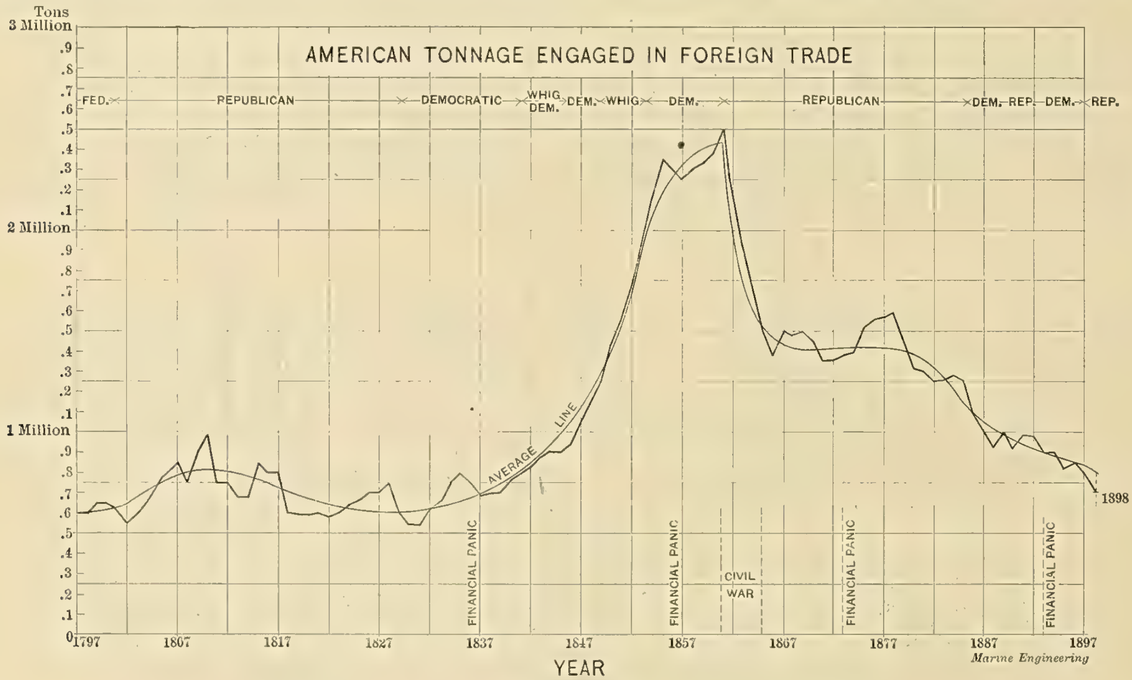


DIAGRAM A.

mary cause of the decline of our marine in foreign waters, it may be pointed out that Britain had been quietly engaged in developing her large mineral resources and employing them in the construction of iron vessels which, entering into competition with our wooden vessels, ultimately drove them out of business. Had the civil war not occurred it is more than probable that this country would not have permitted Britain or any other nation to excel her in the construction of vessels of iron—knowing as she did of the immense stores of mineral wealth which lay buried in her lap, and which only required a concentration of capital and genius to raise and develop. But it was not to be, such considerations were thrown patriotically aside and Britain seized her opportunity and secured the pre-eminent position until then held by us as a shipowning and shipbuilding nation. As a result our tonnage in foreign trade dwindled down

AMERICAN TONNAGE SOLD TO FOREIGNERS.

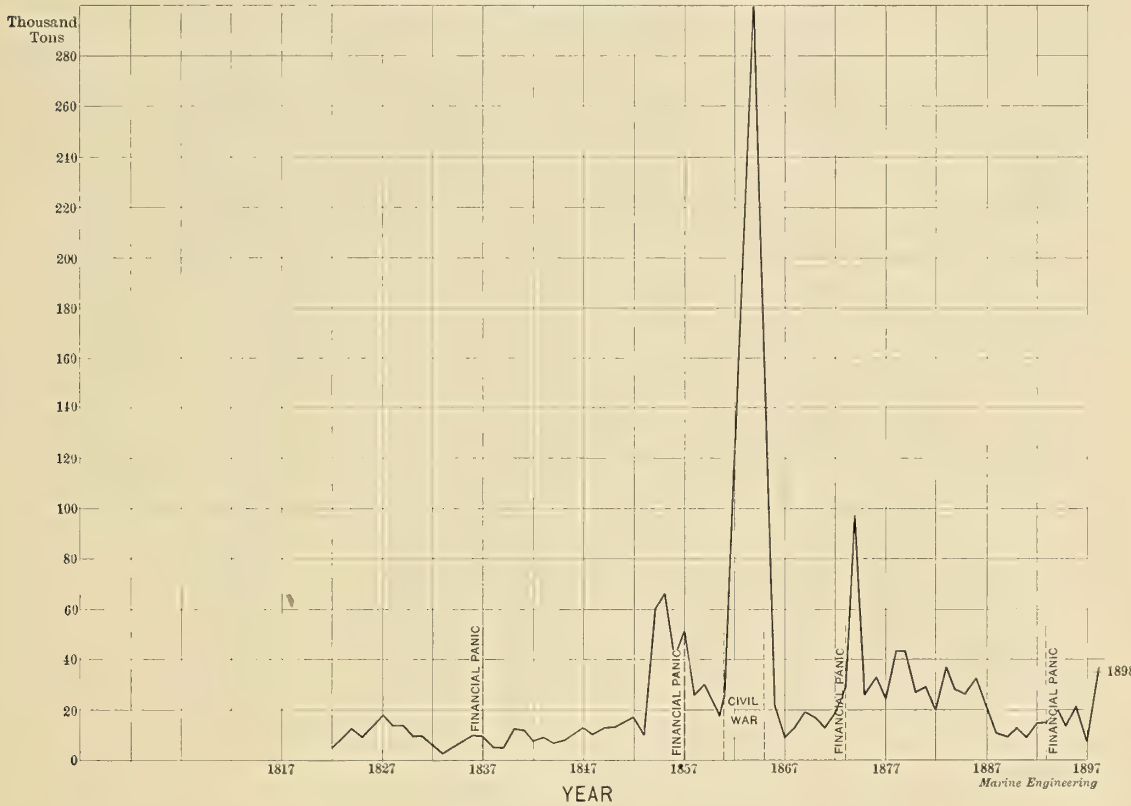


DIAGRAM B.

CLEARANCES OF AMERICAN AND FOREIGN TONNAGE AT UNITED STATES AND BRITISH PORTS.

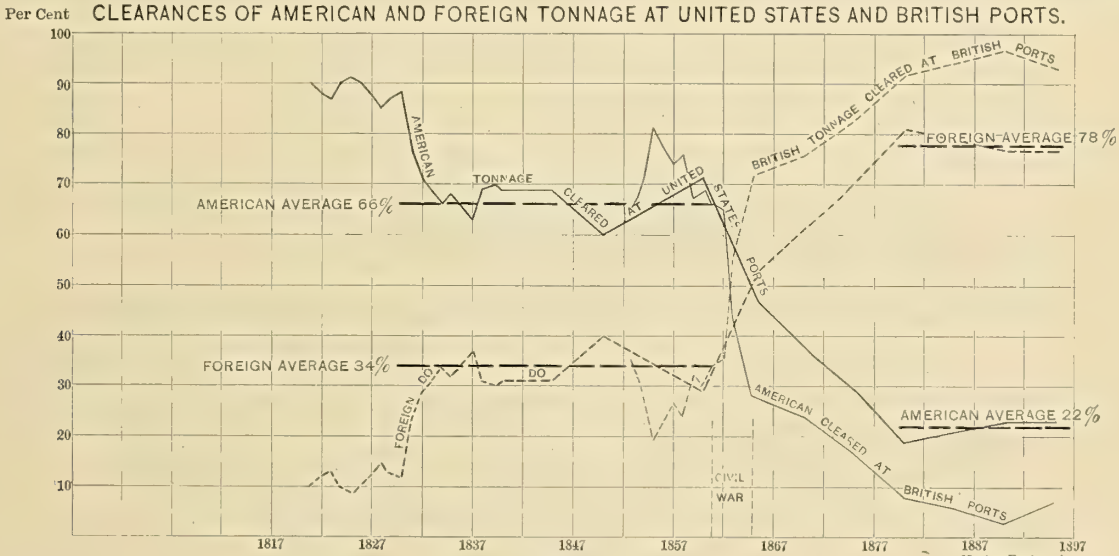


DIAGRAM C.

to 725,200 in 1898, a drop of 1,774,800 tons from the maximum of 2 1-2 million tons.

Diagram *B* is auxiliary to diagram *A*. It shows the amount of American tonnage sold to foreigners year by year during the period 1821-1898. As will be noted on inspection the annual sale from 1821 to 1861—on an average about 12,000 tons per annum—was not greater than might be expected, from an ordinary trading and bartering standpoint; but the sales from 1861 to 1896 tell only too well the story illustrated by diagram *A*. It is interesting to note that if the sales of each year from 1861 to 1896 be added together the total amounts to 1,550,000 tons, which is within 120,000 tons of the difference of 1,670,000 between the maximum and minimum tonnage engaged in foreign trade, already referred to; the discrepancy of 120,000 could probably be accounted for by losses from collisions, wrecks, etc.

Diagram *C* consists of two sets of curves, one set showing the percentage of American and foreign tonnage cleared at American ports, the other set giving the percentage of American and British tonnage cleared at British ports. These curves show in a comparative manner our position, past and present, in the foreign carrying trade; the clearance of American tonnage cleared at American ports being on an average about 66 per cent from 1832 to 1861; from 1861 to 1879 it dropped down to about 22 per cent, and this it has maintained as an average, showing a slight rise at the present time. The clearance of American tonnage at British ports amounted to 66 per cent in 1861; from this it dropped rapidly downwards until, in 1890, it was only 3 per cent, reaching 8 per cent in 1895. As in diagrams *A* and *B* the curves of diagram *C* point conclusively to the civil war as being the primary cause of the decline in the foreign trade.

Turning our attention to the condition of our own coasting trade during the same period, diagram *D* shows the tonnage of American shipping in our coasting trade from 1797 to 1898. Starting at 1797, we find 237,500 tons engaged, increasing at a uniformly rapid rate to an average of about 800,000 tons in 1827-1828; here a sudden drop took place, lasting for a year or so, when we notice the average assuming an upward tendency, once more rising at a phenomenally rapid rate (receiving a slight check during the period of the civil war) until it reached a maximum of 3,380,000 tons in 1865. From that year a decline on the average will be observed, this being probably due to the aftermath of the civil war, emphasized and extended by the financial crisis of 1873. Remaining stationary around an average of 2 3-4 million tons for a year or so, it started, in 1882, to ascend again until, in 1893, we find our total coasting tonnage amounting to 3,854,000 tons. The crisis of 1893 lowered it a trifle in 1894, but it rose again in 1895 and continued on the rise until 1898, when it reached 3,959,702 tons.

A study of this diagram will prove that from the most remote times the development of our coasting

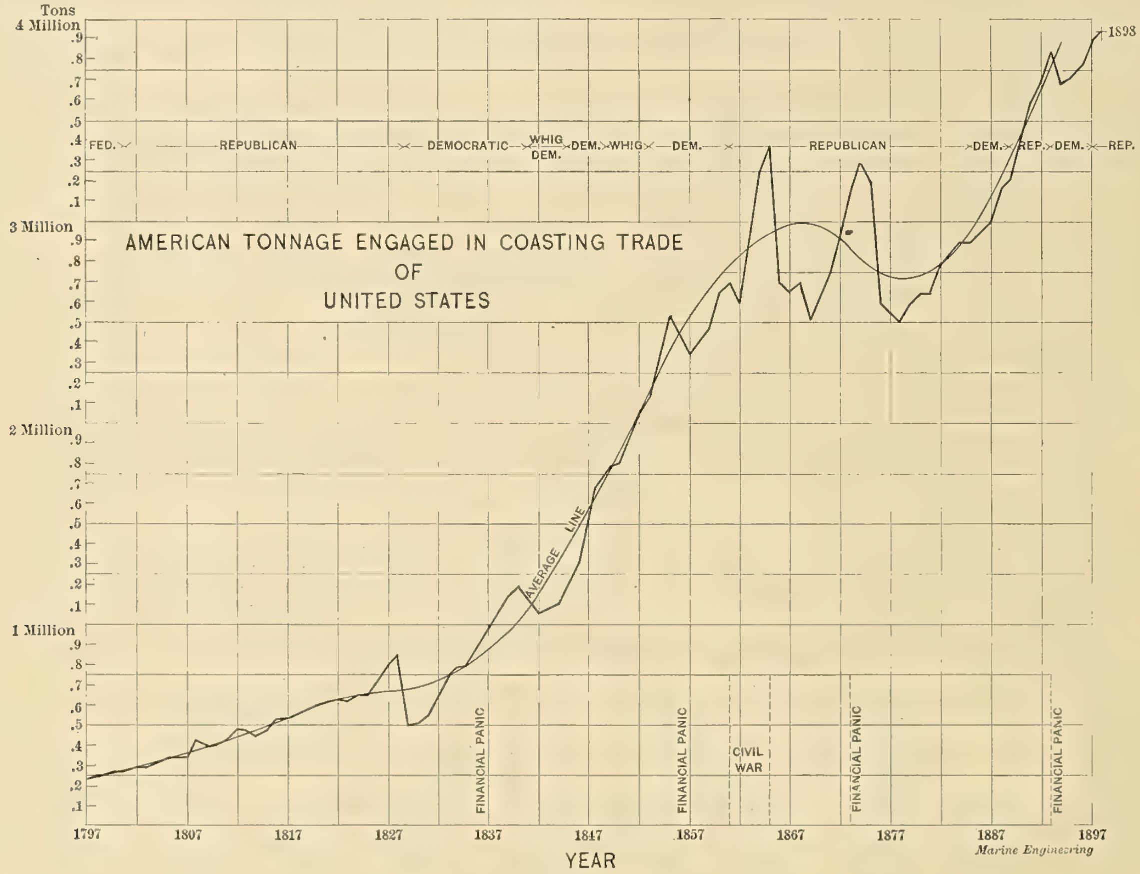


DIAGRAM D.

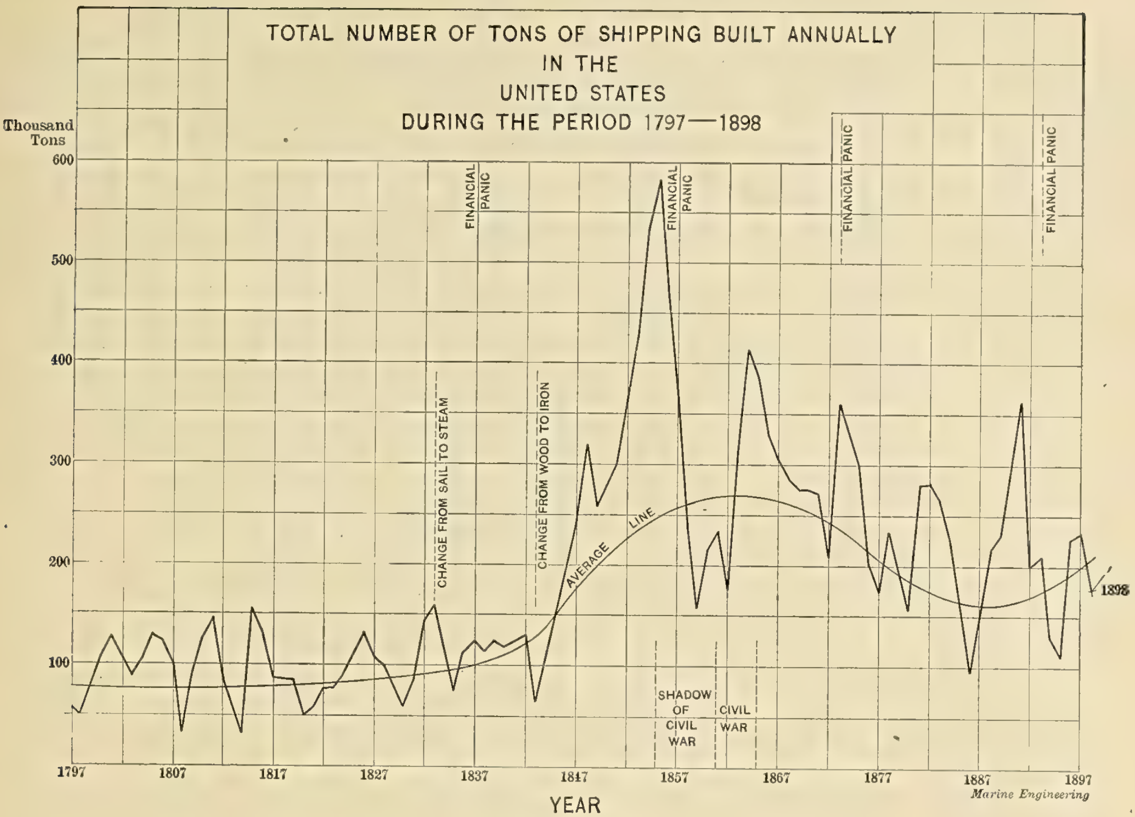


DIAGRAM E.

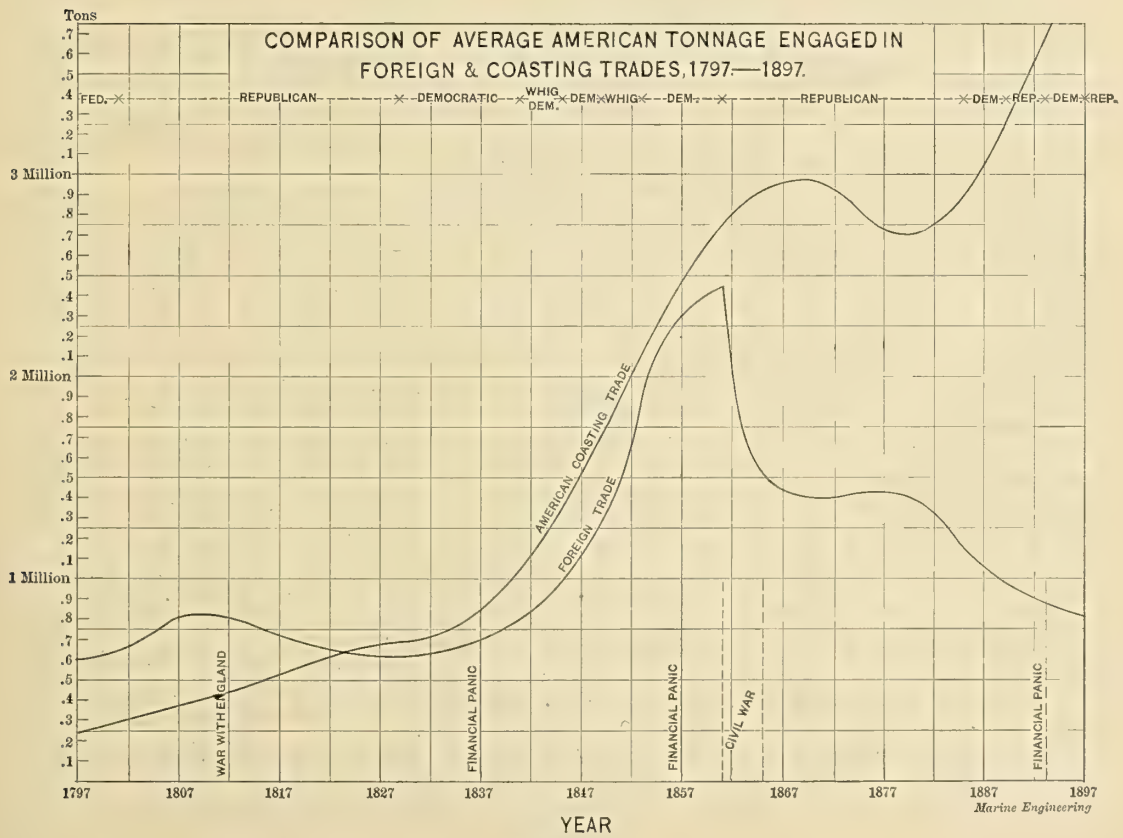


DIAGRAM E_2.

marine has been rapid and uniform; even the civil war, comparatively speaking, had little effect on its growth beyond unsteadying it for ten or twelve years, after which it resumed its march of progress and development with full vigor, and it is in this splendid condition that we find it at the present day.

Diagram *E* 2 shows the average curves of diagram *A* and *D*, forming an interesting comparison between the progress of two leading sections of our Mercantile Marine.

We have reveiwed the conditions of our Mercantile Marine, and have learned that our coasting service is on a solid foundation and in a flourishing condition, increasing at a greater rate than at any other time during the past 100 years, and we know that with the enormous development of all branches of industry and commerce, which is in progress throughout the country, that its future is well secured.

As to the future of our foreign trading, this is a problem involving consideration far too complex to admit of full discussion here—the subject is largely an experimental one. In the past few years there has been an awakening of general interest in the matter, and various schemes and projects have been evolved looking towards its resuscitation. The main question is: What are the obstacles that stand in the way of its future development? Shipping people answer—impossibility of competing with foreign built and foreign owned vessels, claiming that vessels are built cheaper abroad and that owing to smaller wages and rations the foreign vessels cost less for running expenses. Are these obstacles insuperable? The writer is decidedly of the opinion that with properly organized and efficiently conducted ship and engine building concerns we should be able to produce vessels as cheaply and efficiently as our European rivals—we are doing this already in other engineering activities; why not then in shipbuilding? As to the running expenses of vessels there is no doubt that, in order to overcome this obstacle, shipowners must get assistance by legislation. A discriminating duty bill has been passed, and other schemes for Federal aid are under consideration, but while such measures, if enacted, may help, something more direct in its action and effect must be done. Mail subsidies are all very well in their way, but they benefit only a certain class of vessel, which, after all, is not the backbone of a real commercial marine. Something must be done for the freight steamer to enable it to compete with the cheaper run foreigner, and that something, in the opinion of the writer, must be in the form of tonnage bounties for American built and American owned vessels. With the awakened interest in our shipping matters that is being shown on all hands at the present day, it is to be hoped that legislation in this direction will be passed in the near future, and from the date of passing such measures the ultimate supremacy of the United States as a maritime commercial nation will be undoubtedly assured.

Having in the preceding studied the conditions of shipowning, we will now turn our attention to its twin sister—shipbuilding—in which as a national industry we are primarily interested.

Diagram *E* has been prepared to show the total

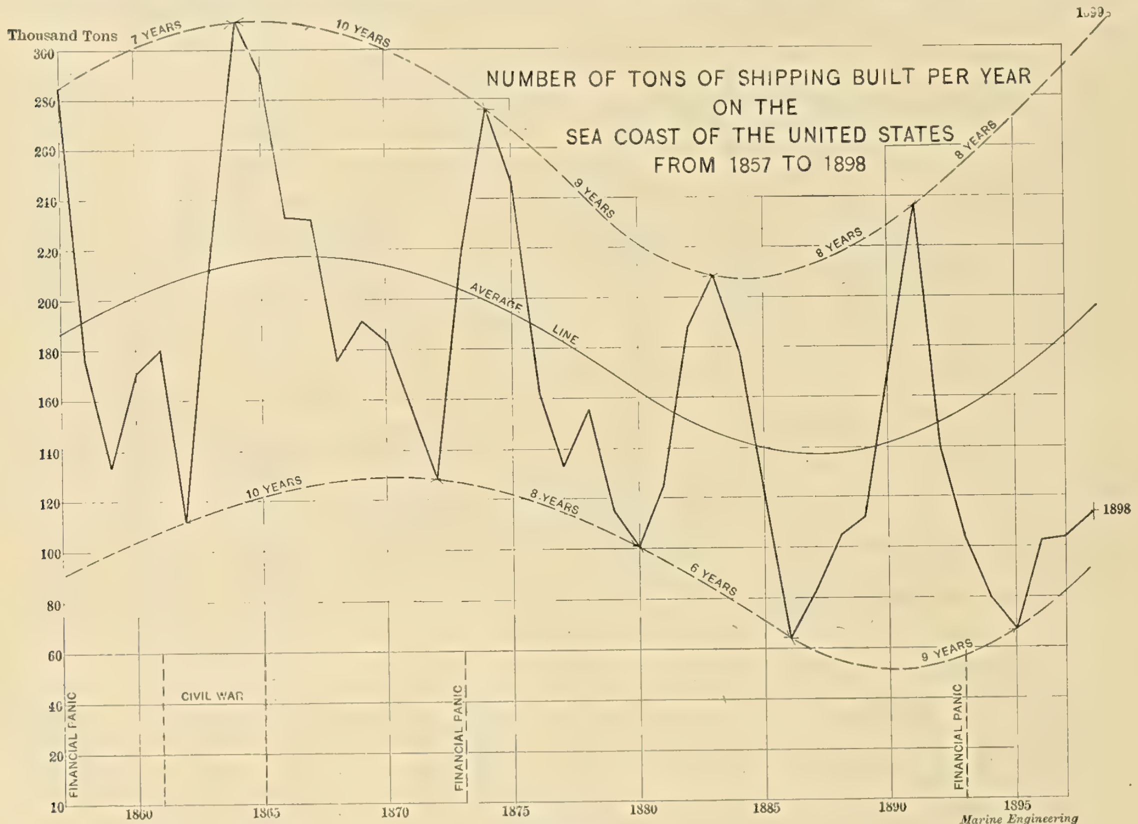


DIAGRAM F.

number of tons built annually in the United States from 1796 to 1898, inclusive; following the progress of shipbuilding, as indicated by the average line, we note a steady increase right along the march of years from 1797 up to about 1863 or 1864. From this point on there is just as rapid a decline until 1886, when the curve ceases to descend and takes a rapidly ascending path, which it is pursuing at the present time. As we are chiefly interested in the present discussion in the shipbuilding on the coast, diagram *F* shows the building progress on the coast of the United States from 1857 to 1897; it will be observed on inspection that the mean line of building on the coast has the same general characteristics as that shown on diagram *E*, a rapidly increasing tendency to rise being distinctly shown from 1886 and continuing upward at the present time.

The following excerpt from the report of the U. S. Commissioner of Navigation for 1898 bears out in a remarkable degree the opinions of the writer as to the brilliant future in prospect for the commercial marine of the United States:

The additions to the merchant fleet of the United States during the current fiscal year will exceed the increase during any year in our recent history. The year of our greatest construction was 1855, when 2,027 vessels of 583,450 tons were built. Since the civil war our greatest annual output was during 1874, when 2,147 vessels, of 432,725 tons, were built. The largest annual increase of late years was the addition of 1,411 vessels, of 392,658 tons, in 1891. The additions from all sources to our merchant marine for the year ending June 30 (1899), it may be predicted, will amount to nearly 400,000 tons. The outlook for domestic shipbuilding, as indicated, is favorable, and the output of our yards should exceed 250,000 tons. Of the 62,000 tons of domestic merchant shipping purchased by the Government to meet the temporary exigencies of war, a considerable proportion will doubtless soon return to commercial pursuits. Of the foreign shipping directed by Congress in June to be documented, about 20,000 tons were not reported before the close of the fiscal year, and will, accordingly, be included in this year's figures. Vessels condemned as prize during the recent war, and entitled for that reason to American registers, aggregate nearly 20,000 tons, of which nearly all have been or will be documented during the current year. Congress, it is assumed, will provide at an early day, a method for awarding American documents to vessels which before annexation were under the Hawaiian flag. The measures adopted after the Louisiana and Alaska purchases are reproduced in Appendix K (*see Report*). The Hawaiian registered list on August 23, 1898, consisted of 62 vessels, of 31,543 tons. Upon the establishment of permanent American control over the Philippines and Porto Rico measures will be necessary to bestow the American flag on the vessels belonging to those islands. The Philippine merchant fleet consists of 93 vessels, of 19,966 tons, but Porto Rico is practically without home shipping. . . . The addition to our fleet from foreign sources mentioned, with some noteworthy exceptions, almost wholly on the Pacific, will be small vessels, adapted to coasting or interinsular communication. The registration of the complete fleet of Northern Pacific Company and the balance of the fleet of the Pacific Mail Steamship Company, by special acts of Congress, and the transfer to the Pacific coast of four American steamships hitherto engaged in transatlantic trade, indicate preparation on the part of the United States to take the lead in transpacific navigation.

It has been frequently claimed that the change from sail to steam, occurring about 1833, and the change from wood to iron were the leading causes for the decline in American shipbuilding; but, as will be noted on inspection of diagram *E*, the rate of increase in the annual output of new vessels, from the time these changes took place, was greater than the rate of increase previously, up to 1855 (in which year was produced the largest amount of tonnage in the history of the nation, 585,000 tons). As has been shown in the discussion of our shipowning interests, however, in this year the nation began to feel the first real tremblings of the impending civil war, a spirit of uneasiness in financial circles ensued, and from this point the annual output followed the same course of decline as originally shown to have taken place in our shipowning interests. It was not the lack of ability either in providing the proper materials or in the skill of the American artisan that caused the decline in construction of vessels; it was due to circumstances momentous to the nation, and direful to the industry, creating opportunities which were eagerly seized by our British rivals.

Now, from the shipbuilder's standpoint, what are the conditions which exist at the present day?

As has been clearly shown, shipowning interests are distinctly on the increase, both in our foreign and domestic trades, legislation is assured in the immediate future which can have no other effect than that of increasing the rate of progress; the chief materials used in ship construction—steel and iron—are being produced at prices equally as low, and in some cases lower, than in Europe; the machinery used in the manipulation of both the metals and wood is superior and more efficient than that used in the majority of ship and engine building concerns on the other side of the Atlantic, and with the vast mineral resources of the country in the first place, and the world acknowledged ingenuity of the American people in the second, and the determination not to be beaten in the third, the process of cheapening the cost of production cannot fail to go on. It is true that the labor costs more in the United States (probably from 10 per cent to 15 per cent) than in the United Kingdom, but with properly arranged systems and methods of work established the labor bill can be readily reduced. It has been already proved by the construction of the new vessels for our navy that we are able to produce vessels of this class equally good in every respect, and as cheaply as those of foreign nations. The building of freight steamers requires only certain modifications in our systems to be equally successful.

Referring again to diagram *E* a feature will be observed which is common to all activities in engineering industries, that is periodic fluctuations. On inspection we observe maximum points of production; starting at 1857 these occur at intervals of 7, 10, 9, 8, and 6 years—a mean of 8 1-2 years, and minimum production at intervals of 10, 8, 6 and 9 years, an average of 8 1-4 years; from the experience then of the past forty years we may safely predict a maximum production to occur about 1899; we touched the bedrock minimum in 1895 and are unquestionably on the rise.

Summing up the preceding, it may be claimed that our shipping interests are in a rising condition, and the capitalist looking for a solid paying investment need have no hesitation in placing his money in the ship and engine building industries, and, as has been shown, the present time is most opportune, the beginning of flood tide.

FULL POWERED SEA-GOING STEAM YACHT APHRODITE FOR COL. OLIVER H. PAYNE, OF NEW YORK.

BY WILLIAM A. FAIRBURN.

The single screw steel steam yacht *Aphrodite* is the largest and finest steam pleasure craft that American designers and builders have as yet produced. This handsome vessel has been constructed by the Bath Iron Works, of Bath, Me., C. R. Hanscom, general superintendent, for Colonel Oliver H. Payne, of New York. The contract was signed early in January, 1898, and a month later the contractors commenced the erection of a steel-ship shed 312 ft. long and 51 ft. wide, in which to construct the vessel. The keel of the yacht was laid in June, and on the first day of December, the steel hull being then practically completed, she was launched and christened *Aphrodite*, by Miss Vivien Scott, the daughter of the yacht's commander, Captain C. W. Scott, formerly of the steamer yacht *Eleanor*.

The dimensions of the *Aphrodite* are:

Length over all including bowsprit	344 ft.
" " " hull	302 "
" L. W. L.	260 " 4 in.
Beam molded	35 " 6 "
Depth, side, moulded	21 " 4 "
" center "	22 "
Normal cruising draft	15 "
Load draft	16 "
Displacement	2,000 tons.
Ratio of length to beam	7.32
" " " " depth side	12.2
" " " " " " center	11.81
" " beam to draft normal	2.37
Gross tonnage Custom House measurement	1,148
Net " " " "	654

DETAILS OF CONSTRUCTION.

The steel hull of the vessel is very heavy and rigid, and the scantlings are in excess of the requirements of any classification society. She will receive the highest rating at the American Bureau of Shipping and the United States Standard Association. The yacht has a flat keel instead of the usual side-bar keel. She has good deadrise, a very easy bilge and graceful curving sides, with a moderate tumble home. The displacement is well proportioned, the center of buoyancy being about amidships, with the ends not too fine. She has a drag aft of 9 in., and the forefoot is cut away somewhat so as to decrease the wetted surface and eliminate weight where there is but little buoyancy. The bow lines flare above the load water line so as to make the vessel more comfortable in a head sea. She has a rounding stern, with a medium overhang, and the stern lines are such as warrant good behaviour when running before a heavy sea. The *Aphrodite* is fitted with large bilge keels or rolling chocks. These keels are 24 in. deep and 140 ft. long. They are formed of steel plates filled with white pine, the thickness varying from 9 in. at the ship's side to 1 in. at the outer edge. As the width of these bilge keels is quite large for a vessel of this type, viz., 24 in., and as the area of the two keels is fully one-twelfth of the area the load water plane, they cannot fail to prove very efficient as rolling chocks. No permanent ballast has been fitted in the *Aphrodite*, as the yacht has ample initial stability, but four large water ballast tanks are fitted, two forward and two aft of the machinery spaces, with a total capacity of 100 tons. The displacement of the vessel can thus be increased and the trim regulated at will. The hull of the yacht is divided into eighteen water tight compartments. There are no less than seven water tight athwartship steel bulkheads extending up to the main deck, and two other bulkheads are water tight up to the lower deck. No doors are cut in any of these bulkheads except where absolutely necessary. The passage from the engine room to the fire room is above the water line, and the doors to the shaft alley and the coal bunkers are the only doors in water tight bulkheads placed below the water line.

There are many innovations in the construction of this interesting vessel. The main deck is plated with steel throughout. The continuous strokes of plating amidships are as heavy as the shell plates, and great care has been taken to place the neutral axis of the vessel as near the center of depth as is practicable. A top-gallant forecastle is fitted forward with full head room between it and the main deck. This forms a covering for the windlass, and in it are also located the petty officers' and crews' W. C., washroom and bathroom. The large deck house, 160 ft. in length, is a steel structure of great strength and rigidity, all the metal work being carefully concealed by handsome paneled mahogany. Vertical sliding air ports 20 in. in dia. are fitted in this house. These are more efficient for an ocean going vessel than the usual rectangular windows, and they also tend to give her a much more shipshape appearance. It has been the intention of the owner to secure ample deck room and freedom at sea rather than large rooms in which to entertain. In this respect the *Aphrodite* is an ideal boat for a lover of the sea. On each side of the deck house there is a clear space of about 7 ft., and there is also a large clear quarter deck, from which one can see the whole length of the ship. The top of the deck house runs out to the side of the vessel, forming a shade deck. This forms a most desirable promenade deck, and it also shelters the walk alongside the deck house on the main deck below.

DETAILS OF EQUIPMENT.

The *Aphrodite* is equipped with an excellent steam laundry and steam drying room. She is also fitted with a very complete ice-making plant. Large refrigerating chambers are located in the forward hold divided into three parts for meat, fowl and fish. These rooms are insulated with 1 1-2 in. nonpareil cork, the woodwork being of spruce throughout. In the afterhold there are six large fresh-water tanks, containing 25 tons of water for "domestic" purposes. Sanitary and fresh-water tanks supplying water by gravity are not placed on the upper deck of this vessel, as is the custom in the majority of steam yachts to-day, but a far preferable constant pressure system has been adopted throughout. There are no less than twelve bath rooms aboard this vessel, and seven of them in the owner's and guest quarters have the floor covered with small rubber tiles, and the sides up to the deck overhead covered with 6 in.

extra quality white glazed tiles, fastened with nickel-plated screws and washers. Each bathtub is supplied with hot and cold fresh and sea water. All the bath room fittings are rich, though plain. The lavatories are oval, with rectangular mirrors above, the water closets are fitted with flushometer valves, and all the plumbing and metal work in these rooms are nickel plated. Shower baths instead of tub baths have been provided for the crew forward, and these rooms are tiled and leaded.

The general arrangement of thé *Aphrodite* was described in detail in the February, 1898, issue of MARINE ENGINEERING. The style and finish of all the rooms already completed is first class in every respect. There is an absence of carving noticeable, and none of the rooms are profusely decorated, yet, at the same time, everything is very substantial, and well and artistically arranged, and the quality of the material used is very choice. The officers' quarters forward are finished in cherry and ash, and the captains room with concealed bath and W. C., excellent desk, bureau and furnishings, is a model.

The *Aphrodite's* electric plant is very complete, two direct coupled generating sets (M. P. 4 — 20 — 550) have been fitted, the voltage being 110. The engines are 6 1-2 in. by 5 in., and the steam pressure 80 lbs. A storage battery with sixty-two cells has been fitted by the Electric Storage Battery Co., of Philadelphia, and the accumulators are placed just abaft the engine room bulkhead alongside the shaft alley.

Two search lights are fitted at the forward end of the shade deck. A Hyde steam capstan windlass is provided for 1 3-4in. chain, with cylinders 9 in. by 9 in. working at boiler pressure. This windless can be operated from the forecastle deck. A hand capstan is on the main deck aft. The main cables consist of 240 fathoms, of 1 3-4 in. stud link chain and 90 fathoms of 1 in. stream chain is also carried. The two bower anchors are of the "Baldt" stockless type, each weighing 4,000 lbs. The steam anchor weighs 1,350 lbs. excluding the stock, and the kedges weigh 675 lbs. and 335 lbs. respectively. The yacht is fitted with a Williamson steam steering engine, located in the engine room, and a Hyde improved Robinson hand steerer is directly connected to the rudder stock.

The *Aphrodite* carries eight handsome boats: viz., one 30 ft. power launch and one 28 ft. power launch built by the Gas Engine and Power Co., two 28 ft. lifeboats, one 28 ft. gig, one 28 ft. cutter, and two 18 ft. dinghies. A very pleasing sail plan is one of the striking features of the vessel. The bowsprit is of steel about 20 in. dia. and 55 ft. long, all the other spars are of carefully selected Oregon pine, with the exception of a few of the smaller ones, which are of spruce. The fore and main lower masts are about 85 ft. long, and the topmasts are 60 ft. long. The lower yards measure 70 ft. and the spanker gaff is 65 ft. long. The total sail area is approximately 16,000 sq. ft., which means that the yacht has about two-thirds full sail power. All the standing rigging

SINGLE SCREW STEAM YACHT APHRODITE, OWNED BY COL. O. H. PAYNE, NEW YORK.

of the vessel is set up by means of manganese bronze turnbuckles, and the majority of these, including all those connected to the shrouds, are finished bright.

PROPELLING MACHINERY.

The machinery consists of a vertical triple expansion engine with cylinders 28 in., 43 1-4 in. and 70 in. dia., and 38 in. stroke. The engine was designed to indicate 3,200 H.P. at about 132 revolutions. The propeller is a four bladed right hand bronze wheel cast in one piece. The diameter is 12 ft. 7 1-2 in., and the pitch is variable. Steam is supplied by four single-ended steel Scotch boilers at 165 lbs. pressure, working natural draft. They are each 14 ft. 4 in. mean diameter, and 12 ft. long. Each boiler is fitted with three 48 in. corrugated furnaces. The total grate surface of the four boilers is 320 sq. ft., and the total heating surface is 9,500 sq. ft.

SPEED TESTS OF THE APHRODITE.

At 7.30 a. m. Thursday morning, March 9, the *Aphrodite* left the wharf of her builders for her official speed test. The machinery of the yacht had been given frequent dock trials during the preceding month, but this was the first time that the vessel had left the wharf under her own steam. The programme for the day consisted of a progressive trial during her run down the Kennebec to the ocean; turning trials in the deep water beyond Seguin Island; progressive speed tests on the measured mile off Southport in the vicinity of Boothbay Harbor, and a four hour full power acceptance trial at sea. The progressive trial made during the run down the Kennebec river was intended to give approximate results and correct a revolution curve which had been previously prepared.

This trial proved very interesting, and as the method adopted of obtaining the speed is new in our country, although it might be considered as merely the development of an old sailor's method, it may be interesting to explain how the results were obtained. Two stations were selected on the starboard main rail of the yacht, and the distance between these stations by careful measurement was found to be 235 ft. The forward one was located just aft of the topgallant forecastle, and the aft station was on a line with the rudder stock. A plane table was located at each station carefully graduated and set square with the center line of the vessel. These plane tables were made for use in the turning circle trials, and each had an arm about 4 ft. long with a vertical sight at each end. During the progressive trial in the river the arms of these tables were set at 90 deg., and therefore a sight base of 235 ft. was formed. An observer was stationed at each plane table with a stop watch that has been previously rated. Electric bells and a carefully arranged code of signals formed the communication between the stations and the engine room. When all was ready for a test, the engine room was communicated with and the revolutions were decreased or increased to the number specified. The pilot kept the vessel for a few minutes on a straight course, and one of the crew at the forward end of the forecastle deck threw overboard, slightly forward and well clear of the vessel, a block of wood. Each observer had his stop watch set at zero, and as the block of wood passed the sights of the respective plane tables each pressed the stop of his watch. One of the observers then took both watches, and placing one in each hand he stopped them instantaneously, and the difference of the readings of the two watches gave the correct time the ship required to cross the base of 235 ft., and from these figures the correct speed in knots or miles per hour was easily obtained. The revolution at the time the speed observations were taken were then reported from the engine room and one spot on the revolution curve was therefore obtained.

On the trial of the *Aphrodite* the cylinders were not indicated during this test and merely speed and revolutions were noted, as it was the intention at that time to give the vessel a very complete progressive speed test on the measured mile at Southport. The following figures are the results of the four tests made by the method described here, and the total time occupied by making these observations and allowing time for the vessel to attain a uniform rate of speed before each set of observations were taken was only about 20 minutes.

TIME BETWEEN SIGHTS.	SPEED IN KTS. PER HOUR.	REV. PER MIN.
11.75 sec.	11.84	104
17.25 "	8.07	72
21 "	6.63	58
24.75 "	5.62	52

As the floating blocks of wood and the ship are always subject to the same currents, etc., all tidal influences are eliminated by this method.

SPEED TRIAL DATA OF STEAM YACHT APHRODITE.

Time.	I. H.P.	Steam.	Rev.	Vacuum.	1 P. Rec.	L. P, Rec.
9.45		155	135	26	42	6
10.	3000	150	132	24½	48	8
10.15		150	135			
10.30	2960	138	131	24½	48	8
10.45		132	128			
11.	2590	125	126	24½	43	6
11.15		122	84			
11.30	2430	155	123	24½	36	5
11.45		162	134			
*12.	3230	152	135	24½	53	7
12.15		135	134			
12.30	2270	120	122	24½	37	6
12.45		122	106			
1.	1470	124	101	24½	23	5
1.15		137	128			
1.30	2780	132	128	24½	47	6
1.45		155				

*M. E. P. referred to L. P. Cylinder = 32.55 lbs.

Upon arriving off Seguin it was found that the weather conditions, whilst quite favorable at that time, did not look very promising, and as the builders were quite confident that the yacht would easily make the required contract speed of 15 knots, it was decided to run the 4 hours sea trial first, and the progressive trial afterwards if the weather remained favorable. The course was from Seguin light with Pond Island light and Mile Ledge buoy in line over to Wood Island light with Old Orchard House and buoy in line a distance of 28 1-2 nautical miles. The depth of water on this course varies from 15 to 40 fathoms, the average being about 25 fathoms. At 9-45-20 o'clock, the *Aphrodite* went over the line. The steam pressure was 155 lbs., and the engine was turning about 135 revolutions per minute. The wild steering of the quartermaster during the first fifteen minutes considerably handicapped the vessel. Although two Sturtevant blowers with 30 inch suctions were fitted on board the yacht, to ventilate all the living spaces and fire room, these were not used to assist the draft during the speed trial. Neither was the draft assisted by the steam jet in the stack, and the trial was in every sense of the word a natural draft trial. The run to Halfway Rock was made at an average rate of speed of 16.7 knots. After passing this point some trouble was caused by the splitting of four condenser tubes, and the revolutions had to be reduced from 130 to about 80. This accident, throughout the remainder of the trial, necessitated the use of some sea water as feed to the boilers, and slight trouble was frequently experienced by a high water level in two of the boilers owing to lack of care in regulating the feed. The end of the course was reached 11-35-20 o'clock, and in spite of a slow down of about 20 minutes and unsatisfactory steering the 28 1-2 nautical miles were covered in 1 hour and 50 minutes, equivalent to a mean speed of 15.5 knots.

The return trip was commenced at 11-46-35 o'clock, and with 152 lbs. steam pressure and 135 revolutions. The first part of the course was covered at a speed of 16.9 knots, and then the vessel had to slow down owing to the advent of a northeast snowstorm; the thick weather making it extremely dangerous to steam at full speed. The compasses had not been adjusted, and as no land was visible, although the vessel was within two or three miles of the shore, the engines were stopped at 1-32 o'clock. The tow boat *Adela* was sighted about this time, and the *Aphrodite* following the tug, seguin rock was located about half a mile distant on the starboard side amidship at 1-40 o'clock. It was found that on the return run 29 1-2 nautical miles had been covered in 1 hour 54 minutes, including all slow downs and stops, which is equivalent to a mean speed of 15.53 knots. The average rate of speed of the yacht, excluding the slow downs and stop, was 16.8 knots, and the average speed throughout the run, including all slow downs and the stop was 15.54 knots, a remarkable performance.

A few days after the official speed trials the *Aphrodite* steamed to New York, where she is at present receiving some of the joiner work for the owner's quarters, which has been constructed by Messrs. Davenport of Boston, the builders of the main cabin of the steam yacht *Eleanor*. The yacht will be cemented and finished in New York, as the Bath Iron Works could not guarantee a satisfactory smooth exterior if the cementing had been done at the works early in March. The *Aphrodite* with her large sail spread and powerful machinery is probably at present the fastest ocean pleasure cruiser afloat. She will be able to steam 16 knots day after day, and her bunkers will carry sufficient coal to allow her to cross the Atlantic at a speed of 15 knots. The *Aphrodite* when she goes into commission will have cost Col. Oliver H. Payne about $450,000, and the running expenses of the yacht will be about $10,000 per month.

VIBRATIONS OF STEAMSHIPS AND METHODS OF BALANCING MARINE ENGINES—V.

BY C. H. PEABODY, B. Sc.

(*Last Installment.*)

In the statement of the kinds of vibrations that may occur in a ship, attention was called to vibrations of higher orders, with several loops and nodes. The simplest vibrations, with two nodes and one loop, have properly received the most attention, as they are the most troublesome; these may be considered to be vibrations of the first order. Vibrations of the first order are caused either by unbalanced engines at or near the middle of the ship or by engines which are not in running balance at or near a node. It has been said that engines which are in standing balance will give little trouble when placed near the middle of a ship, because the rocking couples have little influence at a loop. But vibrations of the second order have two loops and three nodes, one of which is at the middle of the ship. Consequently an engine which is not in running balance may set up vibrations of the second order when placed at the middle of a ship. Again the loops of vibrations of the second order are not very far from the nodes of vibrations of the first order. It may, therefore, be found that an unbalanced engine which has been considered to be unobnoxious when placed near the node of vibrations of the first order, may set up vibrations of the second order if it chances to come at a loop for that order of vibrations. Finally vibrations of the third order have four nodes and three loops. An unbalanced engine at any one of these three loops may set up vibrations of that order, or an engine in standing, but not in running, balance may set up vibrations if set near any one of the four nodes. It seems then that an unbalanced engine set anywhere in a ship may set up vibrations of some order. But since vibrations of the higher order are much more rapid and much less troublesome, they are less likely to occur, and when they do occur require less attention.

For sake of simplicity it has been considered that an engine will set up vibrations only when its number of revolutions is the same as the number of vibrations of the hull of the ship. But it is sufficient that the number of revolutions shall be some multiple or some submultiple of the number of vibrations. That is, vibrations may occur when the revolutions of the engine are half or are twice the number of vibrations. For example, Mr. Yarrow found that a torpedo boat vibrated violently at 200, 400, 600 and

800 revolutions of the engine, while there was little or no vibration when the engine ran at 300, 500 or 700 revolutions per minute. The most dangerous vibrations, however, are found when there is a coincidence of the number of revolutions and vibrations and when the vibrations are of the first order. There have, however, been some instances of very annoying vibrations caused by small high-speed engines; thus one of the United States cruisers had a vertical electric lighting engine placed directly on the protective deck forward. The vibrations resulting were so disagreeable, especially in the officers' quarters, that the engine was removed.

If an engine causes vibrations in a ship when running at a certain speed, then as the engine is speeded up and approaches the time of natural vibration of the hull, the ship begins to tremble at regular intervals, coming to rest between those intervals. The reason for this is that the interval between two fluctuations of the unbalanced force which tends to shake the ship is then only a little longer than the interval between the successive vibrations of the ship. The close approach to coincidence enables the force to set up a vibration which at first increases in violence, because several successive fluctuations can act so as to increase the movements of the hull. But presently the time of applcation of the force lags so far behind the time of the vibrations that it begins to oppose the motion it has itself provoked, and then it tends to quiet the ship. Since there is seldom an exact coincidence of the time of rotation and the time of oscillation, the shaking due to the engines of a ship usually runs through a series of phases, increasing in violence and then becoming quieter. If the ship has twin screws the shaking is further affected by the lack of exact equality of speed of the two engines. When the engines happen to run together the shaking is very violent, but as one engine gains on its mate the effects of the two engines may be so opposed as to partially neutralize each other.

The purpose of the engines of a screw ship is to turn the propeller at a uniform speed. The twist applied by the engine to the screw shaft must be resisted by the hull, and the hull is consequently twisted, though to an imperceptible extent. But the turning effort of the engine is not uniform and the fluctuations of this effort tend to set up twisting vibrations of the hull. These vibrations are noticeable only on very slender hulls, as of torpedo boats and torpedo-boat destroyers. These torsional vibrations have nodes and loops, and may be of the first, second or third order. These vibrations are most noticeable in single-screw boats, for twin-screw engines turning in opposite directions tend to neutralize each other's influence. Schlick says that the arrangement of the cranks of a three-crank engine has little effect on the amount of torsional vibrations, but that the changing of the number of cranks, for example, replacing a three-crank engine by a four-crank engine, may entirely do away with the vibrations because there are then four instead of three fluctuations of turning effort per revolution.

The question now occurs as to what shall be done if a ship shows excessive vibrations when the engine is running. Having determined that the vibrations are proper vibrations of the structure of the hull and are not local vibrations due to lack of local strength or stiffness, it appears that the only remedy is to change the time of revolution of the engine or to change the time of vibration of the hull. It is supposed, of course, that all proper methods have previously been used for balancing the engine either during the design or as a result of experience in running the engine.

Now the time of the engine is the easiest to change, provided that either a slower speed of the ship can be accepted or that the desired speed can be attained with a slower rotation of the engine. To get a slower speed of the engine of a screw ship it is sufficient to increase the pitch of the propeller either by twisting the blades (if they are bolted to the hub) or by making a new wheel (if solid). But in general the engine cannot develop the required power if the revolutions are reduced, so that this method will commonly be impossible. It is true that the same effect can be attained by increasing the speed of the engine by decreasing the pitch of the propeller, but there is then this objection that the ship is sure to tremble violently at some speed less than the full speed, and must always pass through a period of vibration before full speed is attained. And again if for any cause the full speed cannot be attained it will be necessary to reduce the speed below that at which the vibrations occur. Few merchant ships have engines that run so fast as to pass beyond the speed at which vibrations occur, but several cruisers show vibrations when running at something less than full speed, and it is not unusual to find one or more speeds for a torpedo boat at which the vibrations are more troublesome than at full speed.

If the speed of the engine cannot be changed enough to reduce the vibration of the hull, then we must attempt to increase the number of vibrations of the hull by adding new members to the framing of the ship or by strengthening those already in place. It must be borne in mind, however, that additional stiffness rather than additional strength is to be sought, though the method of gaining stiffness is usually to add strength. Of course, it may be possible to reduce the number of vibrations by reducing the stiffness of the hull, but this is objectionable for the same reason that we do not like to increase the speed of the engine, to say nothing of the fact that dangerous vibrations are most common in lightly built ships which it would be dangerous to weaken.

In working out the design for a ship which is to have powerful and high-speed engines so that vibrations may be expected, it is well to calculate the probable time of vibrations of the hull by the equation already given, namely

$$N = C\sqrt{\frac{I}{DL^3}}$$

Of the terms that occur in this equation the length and displacement for a new ship will, of course, be known after the design is well advanced. The moment of inertia is then also determined in connection with calculations of strength. The constant C is not so well known as could be desired; much more experimentation is required to determine this quantity. We may, however, use the equation to estimate the probability of trouble from vibration by aid of the equation when C is not known. Suppose that we have a ship of a given type which does not show much vibration at full speed nor at reduced speeds, so that we are sure that the revolutions of the engine per minute are less than the natural vibrations of the ship. If we use the revolutions of the engine R in place of N in the foregoing equation, together with the length displacement and moment of inertia of the midship section, we may calculate a trial value of

$$C = \frac{R}{\sqrt{\frac{I}{DL^3}}}$$

Taking I^1, D^1 and L^1 from the design of the new ship, we may find

$$R^1 = C\sqrt{\frac{I^1}{D^1 L^3}}$$

which will be a probably safe number of revolutions for the new ship.

Roughly we may consider that the displacement of a ship is proportional to the length and that the moment of inertia is proportional to the fourth power of the depth, which in turn may be considered to be proportional to the length. This makes the number of vibrations of the hull proportional to the length of the ship. This rough method can be used only when the new ship is really an enlarged copy of the existing ship with like proportions.

Somewhat elaborate instruments have been devised by Yarrow and by Schlick for measuring and recording the vibrations of ships. They consist essentially of a heavy weight hung on a long spring so that the natural vibration of the weight on the spring is very slow. The weight is consequently little affected by the rapid vibrations of the ship's hull and remains practically at rest. The frame which supports this suspended weight carries a paper drum which is driven by clock work. A pencil on the suspended weight presses against this paper, and when there are no vibrations draws a straight line. When this instrument is placed at the node of a vibrating ship, the paper, being on the frame, moves up and down with the ship, while the pencil on the suspended weight is at rest. The consequence is that the pencil draws a wavy line on the paper, which indicates at once the extent and the number of vibrations of the hull, since the paper on the drum is drawn along at a known uniform rate by clockwork. If the instrument is moved from place to place the nodes and loops may be located. A modification of this instrument is used to investigate horizontal vibrations. A very simple device, like a weight at the end of a long piece of india rubber, supported by a simple frame or even held in the hand, may be used to locate nodes, and if vibrations are not too rapid may be used to count the number of vibrations per minute, remembering that it is easier to count double vibrations. It would appear, however, well worth while to make careful investigations of vibrations of ships with proper instruments and competent observers.

Warrant Machinists in U. S. Navy.

A circular has been issued by the Navy Department giving information regarding the appointment of warrant machinists, which reads as follows:

NAVY DEPARTMENT,
WASHINGTON, D. C.

REGULATIONS FOR THE APPOINTMENT OF WARRANT MACHINISTS.

In pursuance of the fourteenth and fifteenth sections of an act passed at the third session of the Fifty-fifth Congress, approved March 3, 1899, entitled "An act to reorganize and increase the efficiency of the personnel of the Navy and Marine Corps of the United States," applications will be received by the Navy Department for the appointment of warrant machinists.

2. By the terms of the act, the examination preliminary to appointment is open, first, to all machinists by trade, of good record in the naval service, and if a sufficient number of machinists from the Navy are not found duly qualified, then any machinists of good character, not above thirty years of age, in civil life shall be eligible for such examination and appointment to fill the remaining vacancies. The Navy Department will, therefore, first conduct an examination of candidates selected from machinists of the Navy only. Later, if a sufficient number to fill the one hundred positions authorized by the act fail to qualify, another examination, open to machinists in civil life, will be held.

3. Applications for naval machinists must be made to the Secretary of the Navy, to the commander-in-chief of a fleet or commandant of a station, and forwarded through the official channels prescribed by the U. S. Navy Regulations. No person will be examined who is not a citizen of the United States.

4. With each application there must be, either in the form of endorsements attached to the application or of separate letters, statements of opinion from the commanding officer and the engineer officer under whom the candidate is serving at the time of making his application. These opinions will be limited to the question of whether or not the applicant is regarded as qualified for the position of warrant machinist and worthy of such advancement. Similar letters or endorsements must be obtained by the candidate, wherever practicable, from commanding officers and engineers with whom he has formerly served. The conduct and efficiency reports on file in the Navy Department will also be consulted in making up the candidate's record. All candidates will be required to pass a satisfactory examination before a board of naval surgeons as to their physical fitness for the service. Medical records of the candidate may also be consulted by the examining board in cases where other qualifications appear equal.

5. The candidate must be able to write a legible hand and have sufficient knowledge of arithmetic to enable him to keep the engine room log-book, and an account of stores when necessary. His ability to write English will be judged from examination papers in other subjects. The examination in arithmetic will be limited to the addition, subtraction, multiplication and division of whole numbers, and of vul-

gar and decimal fractions; the reduction of common fractions to decimals; proportion or the rule of three and in the mensuration of surfaces and solids of the regular forms.

6. In engineering the candidate must be able to describe the types of marine engines and boilers, and their attachments, now in common use; the manner of putting them in operation, and the precautions to be taken to guard against the derangements to which they are liable. He must show himself familiar with the uses, operation and construction of the various auxiliary machines now in use on board ships of war; such as air and circulating pumps, feed pumps, fire and bilge pumps, wrecking pumps, hydraulic pumps, forced draft and ventilating blowers, dynamo engines, evaporators, distillers, ice machines, starting and turning engines, anchor engines, steering engines, boat and deck winches, launch machinery, ash hoists, etc. He must be familiar with the materials of which the different parts of machinery, steam pumps particularly, should be made, and he must be able to describe the repairs and remedies usually adopted on board ship in cases of derangement or breakage to parts of main and auxiliary machinery, He must be a practical steam fitter and capable of making joints in high-pressure hydralic piping. He must be familiar with the manner of taking indicator cards from steam engines and must be able to interpret and work out such cards. He must be able to read drawings, make working sketches, and lay out work.

7. The examination shall be competitive, and the time when it is to be held will be designated by the Navy Department. A series of questions covering the subjects above enumerated will be prepared and sent to all ships and naval stations of the United States where enlisted mechanics are on duty. Using these questions, and no others, written examinations of candidates shall be held under the supervision of an officer or officers designated for the purpose by the senior officer present. All candidates on any ship or at any section shall be examined the same day and at the same time. Communication between candidates during examination shall not be allowed, and either giving or receiving assistance shall at once disqualify the offender as a candidate. The examination papers, together with testimonials and all other records, in each case, shall be forwarded to the Navy Department, where the board, provided for in Sec. 14 of the act, shall mark the papers and grade the successful candidates in their order of merit as shown by the final averages.

8. Examination papers shall be marked on the basis of 1,000 as perfect. The following weights will be assigned to the different subjects:

Naval record	100
Recommendations of commanding officers	200
Recommendations of engineer officers	200
Handwriting	30
Arithmetic	70
Marine engines	100
Marine boilers	100
Auxiliary machinery	100
Indicators and diagrams	50
Working sketches	50
	1,000

JOHN D. LONG, Secretary.

AMERICAN SCHOOLS OF MARINE ENGINEERING AND NAVAL ARCHITECTURE.

COURSES PROVIDED FOR IN THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, BOSTON, MASS.

Description of a Great Modern Technical School Adequately Equipped for Scientific Work—Details of the Courses of Study, the Laboratory Facilitis and the Student Life and Surroundings.

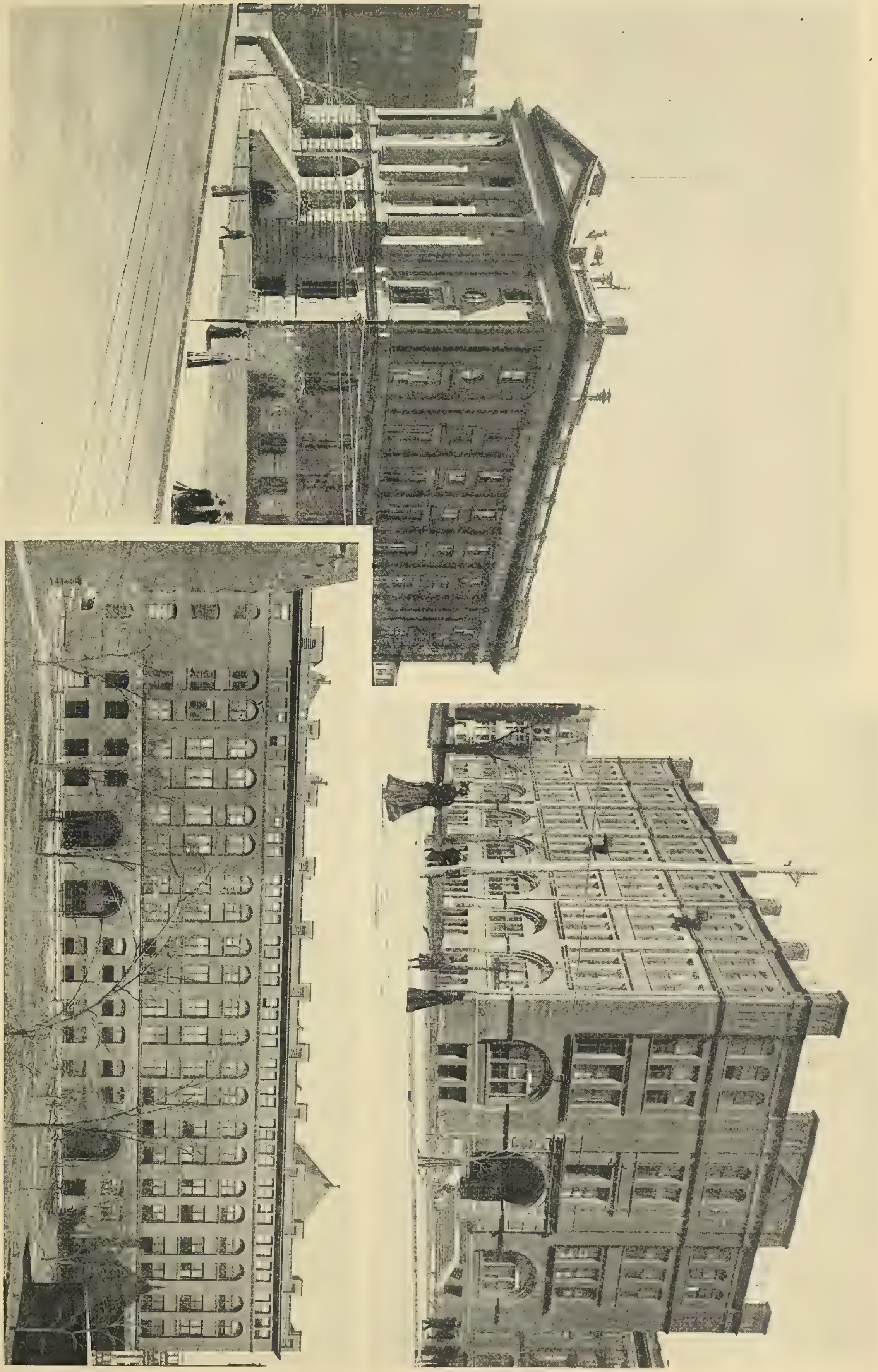
An adequate conception of the purpose, scope and methods of instruction of the course in naval architecture and marine engineering of the Massachusetts Institute of Technology can be obtained only by a consideration of the establishment and development of the Institute as a whole. As the Institute is to a large degree the child of its founder and first president, the late Professor William S. Rogers, his life and personality must be the starting point for any intelligent discussion of this famous technical school. President Rogers was born in Philadelphia in 1804 and was reared in an atmosphere of scholarship, for his father was a professor of the College of William and Mary, and here he commenced his career as a teacher and scientist. In time he became a professor in the University of Virginia, which in its disregard of the old traditions in education was a fit precursor of the Institute—so far removed in locality and so different in many of its aims and methods, but entirely alike in its devotion to truth and sound scholarship.

The original proposition for an institute of technology at Boston sprang from a course of lectures before the Lowell Institute delivered in 1844 by Professor Henry Rogers, a younger brother, to whom Professor William Rogers wrote the following characteristic sentence:

"The true and only practicable object of a polytechnic school is, as I consider, the teaching, not the manipulations and minute details of the arts, which can be done only in the workshop, but the inculcation of all the scientific principles which form the basis and explanation of them."

This and Professor Rogers' early advocacy and persistent support of laboratories of chemistry, physics and engineering can be taken as the foundation of the methods of the Massachusetts Institute of Technology. That the methods have been successful is evident from the reputation of the school and the success of its alumni in wide and varied fields of influence.

The corporation of the Massachusetts Institute of Technology, consisting of a group of prominent men of Boston, with Professor Rogers as president, was organized in 1861; on account of the civil war, however, the regular course of instruction was not opened until 1865. This corporation, of which the president of the institute is a member, owns and manages the property of the Institute, appoints the president, pro-



Rogers Building.

Pierce Building.

Walker Building.

PRINCIPAL BUILDINGS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, BOSTON, MASSACHUSETTS.

fessors and other officers and instructors and grants degrees on the recommendation of the faculty. The facutly establishes and controls the courses of instruction and discipline of the school.

The buildings of the Institute, a familiar sight to Bostonians, are located near Copley Square, in the more modern portion of the city of Boston. They are partly on land granted by the State, and partly on adjacent property purchased at later periods. Not far away are the classical Public Library, the Museum of Fine Arts and the Museum of Natural History, thus forming a center of art, science and enlightenment in a city long noted for its literary and intellectual activities. At first all the departments were contained in the parent building, now called after its founder, Rogers Building; afterward, as the needs of the school increased, the building alongside, known as Walker Building, was occupied, and since the continued growth has necessitated constant expansion until now there are in all seven buildings containing departments of the Institute.

COURSES OF INSTRUCTION.

At the beginning the Institute offered courses in Civil and Mechanical Engineering, Mining Engineering and a course in Literature and Science. Now the Institute offers thirteen distinct courses in Civil, Mechanical, Mining, Electrical, Chemical and Sanitary Engineering and Naval Architecture, in Chemistry, Physics, Geology, Biology, Architecture and general studies, and many of these courses offer options that allow students to develop special branches of their intended profession. The school now has on its rolls about twelve hundred students, who are instructed by fifty-four professors and more than one hundred lecturers, instructors and assistants. This large teaching force is required by the divisions and subdivisions of classes, in the numerous subjects and specialties which make up the courses of instruction, and more especially by the extensive introduction of laboratory methods which have from the first been very highly developed.

The courses may be grouped as the Engineering Course, including the first seven enumerated, and the course in Pure Science, such as Chemistry, Physics, etc.; also Architecture, which has so large an artistic side, and the General Course, which includes literary, economic and similar studies. All these courses have in common a substantial basis of Mathematics, Pure Science, Language and Literature to give a well-rounded general training. Each course, or group of courses, has its further development of Mathematics, Science or Literature along advanced lines as may be required. Students of the largest group, which comprises the engineering courses, while they begin to differentiate at the second year of the course, have a large amount of work in common, including such subjects as Descriptive Geometry, Mechanism, Applied Mechanics, Hydraulic and Steam Engineering. It is held that the engineering student must first of all learn engineering and afterwards add to his knowledge the specialties of the particular branch which he may elect (one of which is Naval Architecture), for the Naval Architect is an Engineer who knows how to build ships.

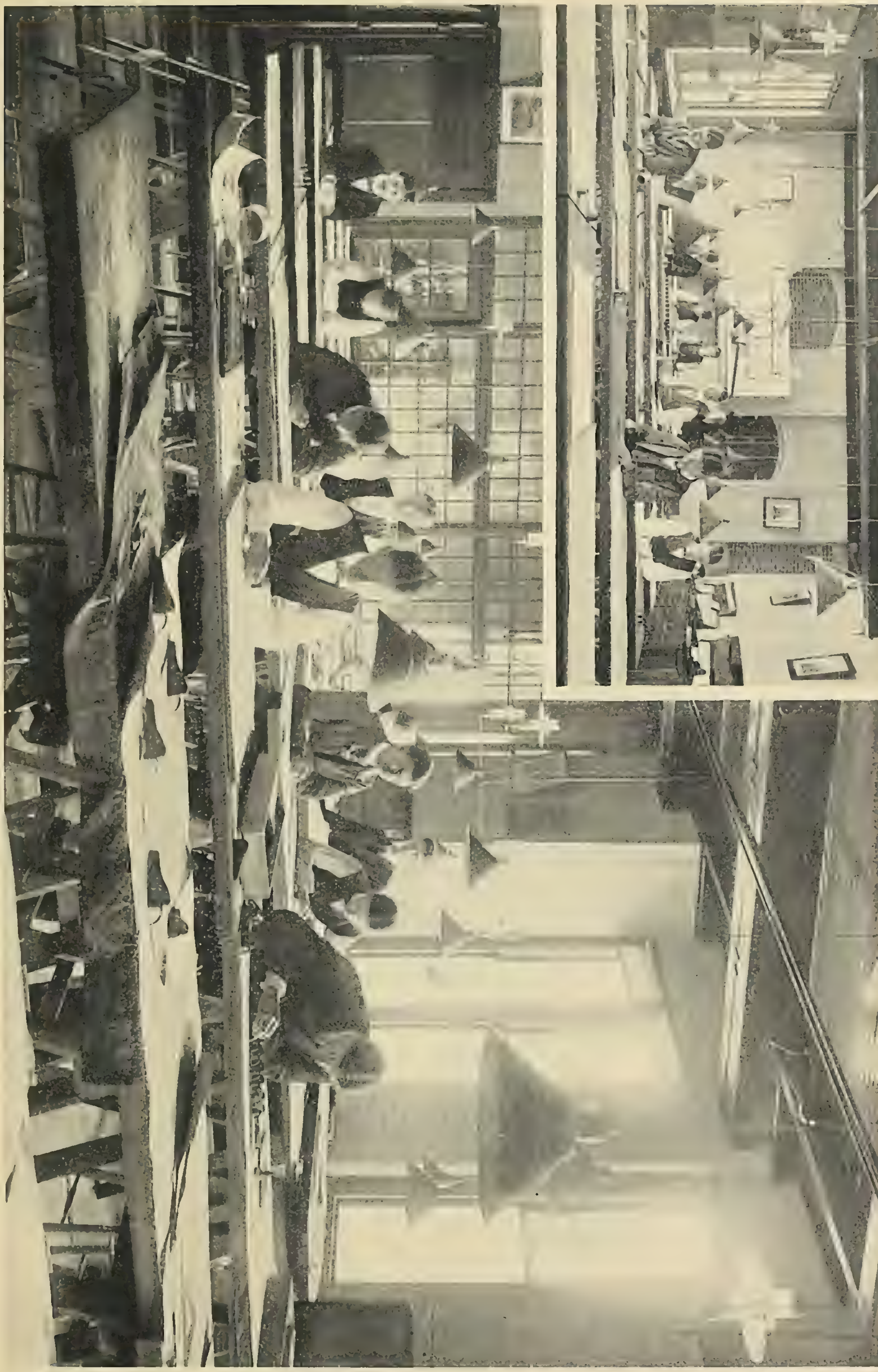
COURSE IN NAVAL ARCHITECTURE.

The inception of the course in Naval Architecture commenced in 1888 from a suggestion by General Walker, during whose presidency the phenomenal growth of the school occurred, that students who took the marine option of Mechanical Engineering ought to know something of the structure and properties of the ship in which are found the marine engines that form the specialty of that option. From this beginning the instruction in Naval Architecture was broadened and was intensified rapidly yet with a conservative adherence to the methods and traditions of the Institute, till, in 1894, it was found possible to offer a complete four years' course covering all the accepted theory of the profession, together with methods of calculation and draughting required for the design of a ship. The department has thus far graduated twenty-six men, of whom twenty or more are in active practice of their profession, and of the small remnant all are in parallel branches of engineering or else have taken up some business from choice. In addition there are a number of graduates who took the undeveloped or embryotic course and have since perfected themselves in their chosen profession, in which they hold positions of responsibility.

Coming now to the course in Naval Architecture in detail: Admission, as to all the courses, is by examination in Algebra, Geometry, History, English and French or German. It is the intention of the authorities that sufficient preparation may be attained in a good high school. A clear admission to any recognized college authorized to grant degrees is taken in lieu of an examination. Students coming from abroad are in general admitted without examination, it being expected that such candidates will inform themselves as to the requirements and satisfy themselves that their general preparation is adequate. Advanced standing may be taken by students, who show that they are competent to take up subjects regularly placed in the higher years.

The course extends over four years; each year beginning the last week in September and ending the first week in June. A recess of ten days is taken after the semi-annual examinations and brief recesses are allowed at Thanksgiving, Christmas and in the month of April. The school year therefore occupies thirty-four weeks, with two examination periods of nearly two weeks each. But so far as appears advisable the progress of students in earlier classes is judged from daily work, with comparatively few examinations.

Instruction is imparted by recitations, lectures, drawing, laboratory and shop work, or by a combination of several of these methods. Many text and reference books have been published by the professors, with special regard to the needs of the school, and there is a large development of printed matter prepared for the use of classes at the Institute only, which is not published; in fact it is the policy to print lecture notes as soon as they take permanent form. The large classes in many subjects allow frequent



STUDENTS OF NAVAL ARCHITECTURE AT WORK IN THE DRAUGHTING ROOM, MARINE DEPARTMENT, MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

revision of such notes, without excessive expense to the students. Notes which have not yet assumed even a semi-permanent form, or which are used only by a small number of the students are duplicated by the mimeograph or some similar process. A sample of these is shown in the engraving. The greater portion of the instruction, indeed, in Naval Architecture is given in mimeograph notes, which have been found very convenient, as changes can be made whenever necessary by the addition or ready substitution of sheets.

The Drawing Room work is arranged to illustrate the theoretical work of the lectures and recitations and is carried on so far as possible at the same time.

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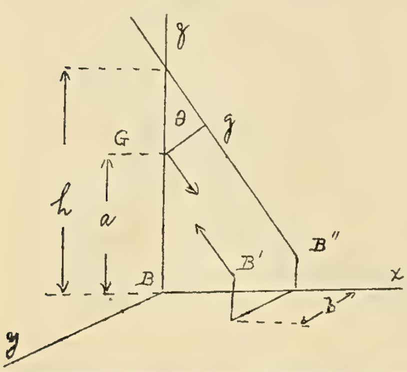
Fig. 50.



metacentre and centre of gravity above the centre of buoyancy B, we may resolve the entire righting moment into two moments

$$D\,(h - a)\sin\theta$$

in the plane of inclination and

$$D\,b$$

which acts about an axis in that plane. The second moment is small for ordinary inclinations of well formed ships, and is usually ignored in the discussion of stability. When desired the longitudinal position of the centre of buoyancy can be found by taking moments about a transverse axis, as in the calculation for the displacement and centre of buoyancy, in the erect position. When the position of B' after inclination, has been located the value B'B" = b Fig. 50, is readily determined and also the moment of the couple D b. In Barnes' method of

SAMPLE OF MIMEOGRAPH NOTES.

In the same way exercises in the laboratories of engineering and applied mechanics are made to enforce the teachings of engineering principles, and reciprocally the lectures are directed to enable the student to undertake various laboratory problems and investigations intelligently. Practice in the Drawing Room, the Laboratory or the Work Shop is so graduated that the first work assigned to a student is well within his capacity, and he is expected and required to do good work from the first. As he gains power more and more is expected of him, each exercise being intended to require his best efforts and to presuppose all the previous instruction to be at his command. This system yields results of the highest quality and finally enables the instructor to demand a large quantity of work without distressing his students. The thesis which completes the course is left almost entirely to the student, who seeks advice and guidance only so far as may be required to avoid unnecessary waste of effort through inexperience.

LABORATORIES AND WORKSHOPS.

The laboratories in the buildings in Trinity Place occupy a floor space of 21,000 sq. ft. The Testing Laboratory is equipped with a number of machines, ranging in size from an 800,000-pound Emery machine downwards, for making tests of the metals, timber, cement, rope, wire, cloth and masonry. The largest machine will take in a compression specimen 18 ft. long and a tension specimen 12 ft. long.

The Hydraulic Laboratory contains several tanks and standpipes, together with a great variety of connections, for ascertaining the loss of head, laws of discharge, velocity of jets, flow in pipes and for weighing the water in experimental work. There is here also a 48 in. Pelton wheel, a Venturi meter and various weirs, meters, pumps, turbines and rams.

In the Steam Laboratory there is a multiple-expansion engine of the Corliss type, with cylinders 9 in., 16 in. and 24 in. dia. and 30 in. stroke, which can be disconnected so as to run simple, compound or triple. There is additional a tandem compound high-speed engine of 250 horse power. These engines are fully equipped with condensing apparatus, and all other paraphernalia necessary for the most exact determinations. Smaller steam and gas engines are used for instruction in valve setting and methods of construction. The minor apparatus includes a great variety of condensers, pumps, injectors, calorimeters, mercurial pressure and vacuum columns, indicators and other measuring instruments.

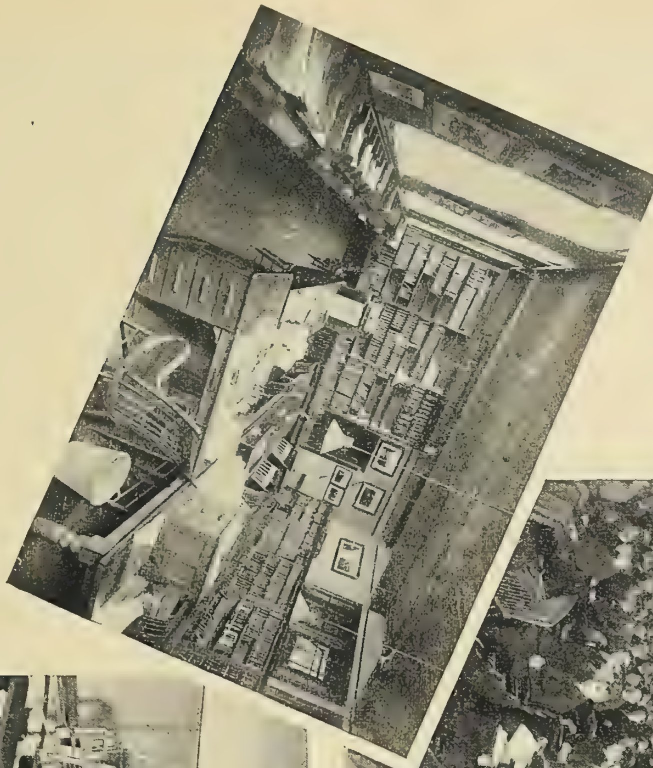
In the laboratories there is also special equipment for experimental work in friction and lubrication, and in the adjacent power house there is a large battery of boilers continually under steam, so arranged as to be available for tests.

The Electrical and Chemical Laboratories are very extensive and contain an immense variety of machines, instruments and apparatus for instruction and special experimentation.

The workshops include: Machine shop, containing twenty-three engine lathes and other machine tools, and also large vice bench space; carpentry, wood turning and pattern making departments, with forty carpenters' benches, buzz, jig and swing saws and other wood working machinery, thirty-six wood lathes, and as many pattern makers' benches; foundry, with cupola, brass furnaces and thirty-two moulders' benches; forge shop, containing thirty-two forges and necessary hammers and drills.

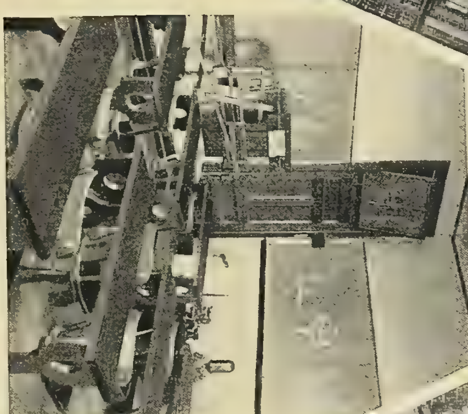
ADVANTAGES OF LOCATION.

Much in the same line is the advantage of the location of the school at an important seaport where vessels of all classes are constantly found at the whaves. Not only that students may find illustrations of the subjects discussed in the lectures and recitation rooms, but that each as he runs across a difficulty in design of a ship or her engines may see for himself how the same or a similar difficulty has been surmounted in a special case. A student who has gone by himself to find how details of design have been

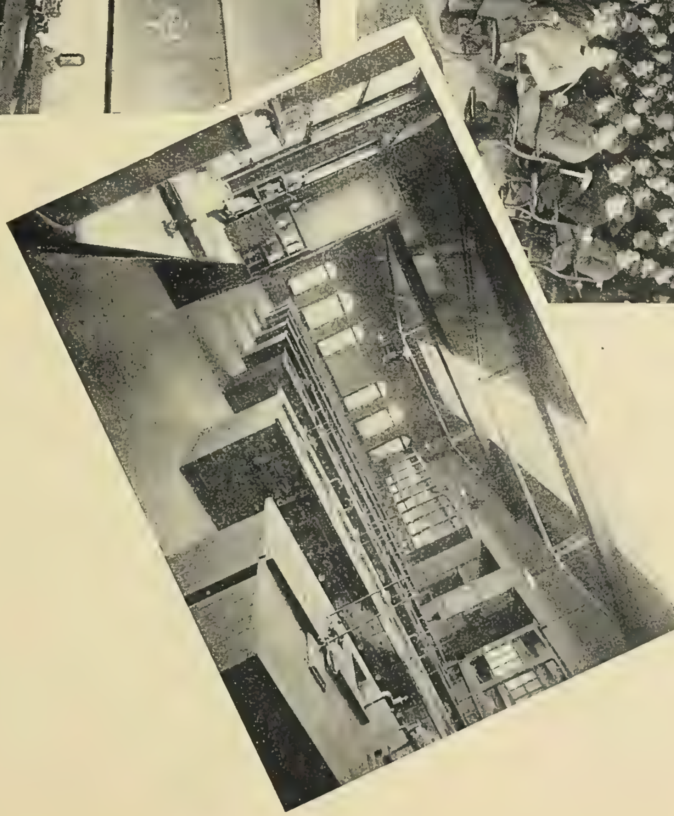


Interior of Special Engineering Library.

Class Attending Lecture in Huntington Hall.



Recitation Room, "Naval Architecture" Course.



First Year Chemical Laboratory.

INTERIOR VIEWS IN VARIOUS BUILDINGS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

worked out not only learns that detail as he cannot from any lecture, text book, or drawing, but has gained what is worth more than all his books, notes and designs, the power to observe and learn for himself. From an instructive point of view also visits to ships which have met with mishaps and come into port with boilers or engines broken or injured are very valuable; for more can often be learned from mistakes or misfortunes than from success. Even a trip down the harbor in the engine room or a steam vessel is not without its value from the zest it gives to the text book discussion of machinery details.

The work constantly in progress at the Boston Navy Yard and in the large marine workshops in the vicinity is of special value in this connection. By the consent of the Navy Department students have for several years been given practice in laying down ships in the mould loft at the Navy Yard.

SUBDIVISION OF STUDIES IN NAVAL ARCHITECTURE.

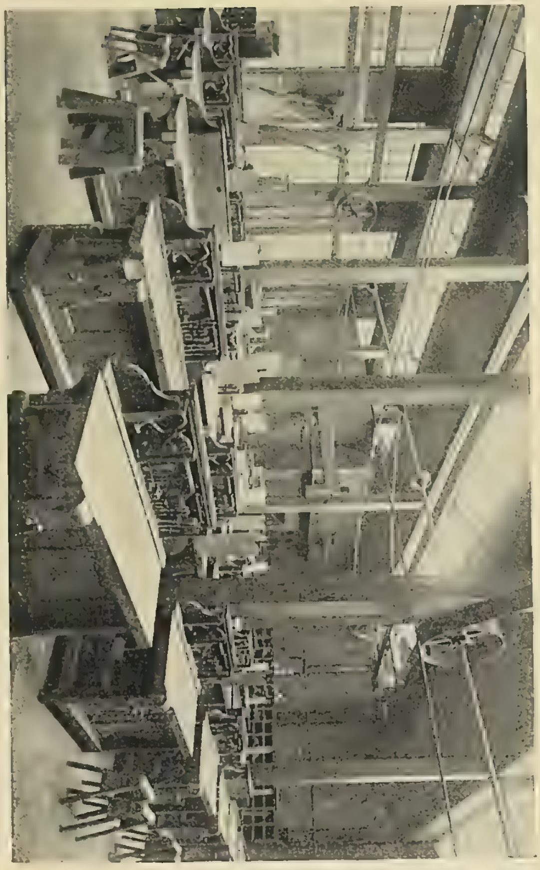
The two first years of the course in Naval Architecture are but little differentiated from the work of the other engineering courses, and lay the foundation in Mathematics, Chemistry and Physics, on which all applied science must rest. The training in common with other such courses is continued in Applied Mechanics and Steam Engineering throughout the third and fourth year. So broad and sound is this training for the engineer at the Institute that many subjects such as the Theory of Integrators, Calculation of Strength, etc., can be either assumed to be familiar to the student when he reaches the specialization in Naval Architecture or may be dismissed after a very brief discussion of their application to ship building. Thus the lecture on Stress and Strains on ships take up only the question of Buoyancy in quiet waters and among waves, and the special devices for facilitating calculations for a ship. It has been found possible, therefore, by a continuous course of two lectures a week throughout the third and fourth years to give adequate discussion of all the accepted theory of the profession, including the General Geometry of Floating Bodies; Statical and Dynamical Stability, with special application to added loads; Carrying Liquids; Bilging Compartments; Launching and Docking; Calculation of Stresses; Rolling in Quiet Water and Among Waves; the General Theory of Waves; the General Problems of Propulsion, including the Influence of Waves made by a ship at high speed; the different Methods of Propelling, by paddle wheels, screw propellors and by sails; Steering and Manœuvering of a Ship Under Steam and Under Sail; Methods of Ventilation, and Adjustments of Compasses. There is given at the same time a sufficient description of methods of construction to enable the student to understand the work which he may see in progress in shipyards and elsewhere, and to intelligently apply the principles of design to a ship. More than this the college does not consider it desirable to undertake, believing that the student must finish his education in the shipyard and the drawing office.

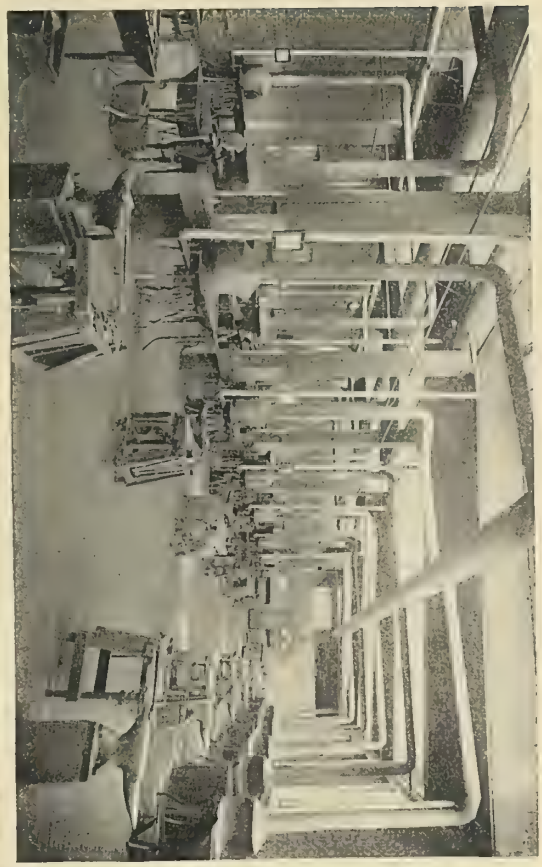
The Drawing Room work is carried on simultaneously with two or three exercises a week throughout the third and fourth years of the course. Beginning with Drawing and Fairing Lines of Ships or Yachts, students make the usual calculations for Displacement, Strength and Stability, and finally make a fairly Complete Design of some special ship, from preference a ship of medium size, large enough to call for all the real problems of a design, but without the multiplicity of detail that might make real design impossible. This department has a fine outfit of Integrators and Calculating Instruments, and machines to facilitate the work of calculation and to familiarize the student with the tools of his profession.

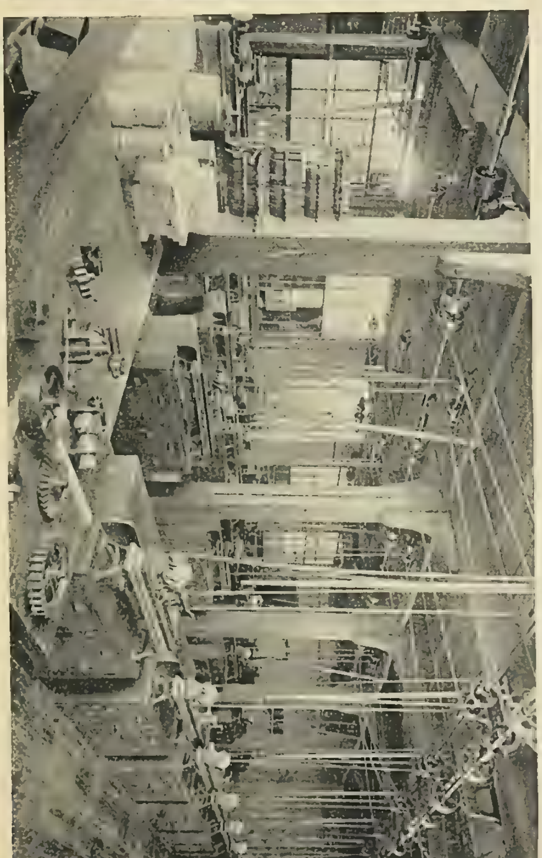
Parallel with this work in Naval Architecture is the work in Steam Engineering, taken by all engineering students, and the work in Marine Engineering, which is taken also by such students in mechanical engineering as may choose that branch for an option. It is considered here that the best co-ordination of the design of the hull and machinery of a ship is one made under the final control of a master of both sides of his profession. Contrary to a commonly accepted idea that there is any essential difference between the construction of the hull and the machinery, the college holds that the work is essentially similar and that no one can completely understand one branch without knowing the other. Whatever separation in practice may be found convenient, it is held to be necessary to carry on instruction in both marine engineering and naval architecture at the same time. In the Marine Engineering course a study is made of the Details of Engine Construction, of Stresses in Engines when running both from steam pressure and from the accelerations of the moving parts, together with a study of the Screw Propeller, of Paddle Wheels and of Hydraulic Propulsion. The students lay out and carry well forward the designs of a marine engine and apply to it the constructions and calculations discussed in the lectures. Students in Naval Architecture practically design, in this connection, the engines for the ship they design in their special instruction in hull work.

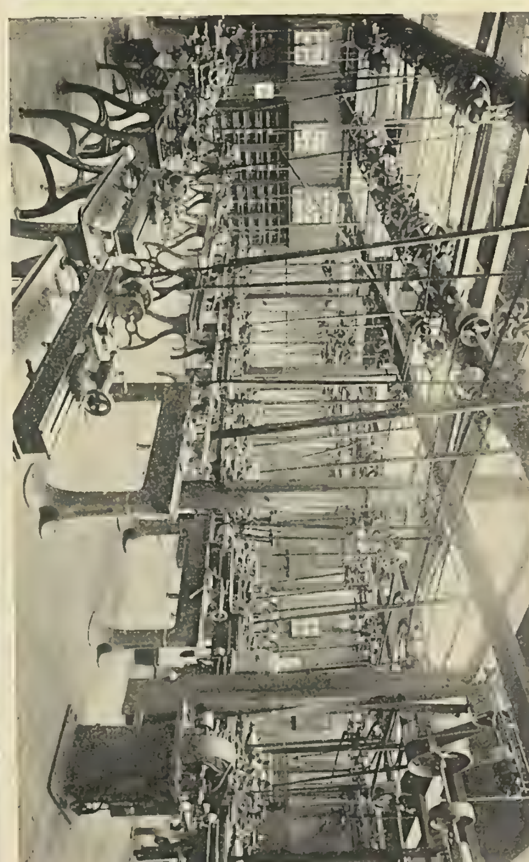
GENERAL EDUCATION OF STUDENTS.

Thus far attention has been given mainly to the work of the students, which is directly in or which bears directly on their own profession. But the Institute does not forget that the bulk of the students must get at the same time their general education which shall fit them to meet other educated men on a level. In one sense a sound engineering education is in itself a liberal education, as it teaches how to observe and learn, but it is recognized that without considerable attention to the "humanities" a student of engineering is liable to have a narrow view. Consequently a course in French and German, in History, Literature and Political Economy is carried through the first three years of the college work. And in the study of languages the end sought is not only to open modern languages to the reader of technical literature, but also and mainly that training in the use of language (including English) that can be best attained by a rigid study of a foreign tongue. The proximity of the Institute to the Boston Public Library (to which students have access) and to other









Looking Down Forge Shop.

Carpentry and Joinery Shop.

General View of Machine Shop.

Lathes in Pattern Shop.

VARIOUS STUDENTS' WORKSHOPS AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

general and scientific libraries in the city afford opportunities for individual research, which are particularly valuable during the preparation of the graduation thesis. The libraries of the institute are working libraries conveniently located near the drawing room or other local habitats of students and are now very complete, each in its own line. Each library has well-kept files of technical periodicals, of which the students make good use. These are particularly valuable in clothing the framework of the regular instruction of the course of study with the records of the life of whatever branch of the profession the student is studying. There is also a large, comfortable and convenient library in the Central Building, which is open at all times, evenings as well as day times, so that no student may lack a light, warm and cheerful place in which to work and read.

STUDENT SOCIAL LIFE.

In the foregoing reiteration of the methods of work, of the requirements of hard and unremitting attention, might lead to the belief that the life of the Institute student was made up of drudging, which in the end would break down all but the gifted. Such is not the case, however, for the amount of time that may be exacted is strictly regulated not to exceed eight hours a day for six days in the week; or the work may be arranged by the student to take half a holiday on Saturday or an occasional evening, as he may desire. The arrangement of studies on alternate days or at longer intervals permits of much flexibility of work. It is true that only a fraction of each entering class persists till graduation, as is evident when there are twelve hundred students in regular attendance, and about two hundred graduated each year, but the loss of any class which takes place mainly at the end of the first year is due in part to inadequate preparation and more largely to a failure of many young men or their friends to comprehend what a technical education is, and whether he has any liking or aptitude for such work. When all is said it must be admitted that life at a technical school is bare and dreary to a young man who does not enjoy his work; the continual grind of distasteful work that is necessary to stay in the classes at all usually eliminates those who have mistaken their calling at the end of a year, and two years finds the classes compact and well drilled as a regular army that is accustomed to working together. In the work itself there is much pleasure and companionship of the best kind for those who can and will bring themselves to a level where the work is a pleasure. Especially is such companionship developed in the latter years, when each in his own chosen specialty meets, daily, and works with congenial fellow students, who understand and share his trials, aims and ambitions. Friendships thus formed in the classes of the Institute have endured the trial of time, and the class associations are maintained and the years are marked off by annual dinners and other functions. Then there are societies of men in the same course, as the Architectural, Biological, and the Civil Engineering and Electrical Engineering Societies and others. Thus far students of the course in Naval Architecture appear to have found the daily association in lecture room and drawing room sufficiently society in itself and there has been no lack of *esprit du corps*. Societies of men from the same city or localities have been maintained for many years, such as the Southern Club and the Chicago Club, etc. Bicycle, canoe and yacht clubs, glee clubs, mandolin and banjo clubs also flourish. Every year the associations for the study of French, German and literature give some theatrical or other form of entertainment. There are many local societies, and also chapters of fraternities, etc. Last, but not least, there is the Young Men's Christian Association, which has a society house where meetings are held.

The students maintain a weekly paper during term time called "The Tech," and the junior class publishes an annual called "Technique." The Institute publishes the "Technology Quarterly," containing articles read before the Society of Arts, and productions of Technology men of all sorts. Then there is the "Technology Review," published by the alumni.

The Technology Club is composed of persons from the corporation, faculty, alumni and senior class. It has a club room conveniently near, where "smoke talks" and other entertainments are held, as well as many class dinners and other reunions.

There are usually thirty or forty young women on the Institute rolls. Many are pursuing specialties to fit them for teaching, to enlarge their usefulness as teachers. Every year there are a few women graduates from the courses in architecture, biology, physics, or chemistry. The young women have a society of their own and a suite of rooms especially fitted up for them.

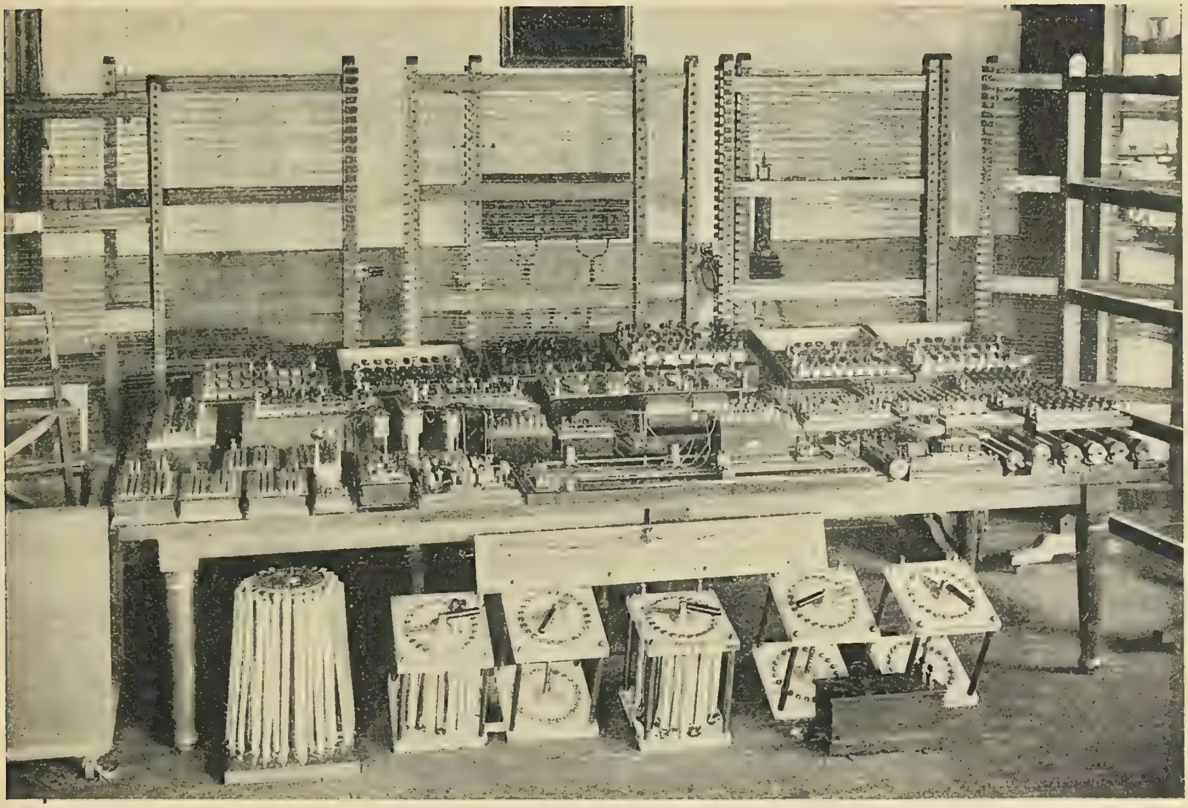
The Institute has a gymnasium, which affords facilities for all kinds of exercise, with baths, etc., and many students make use of the gymnasiums in the vicinity, such as the Boston Young Men's Christian Association gymnasium. From the fact that the majority of the students are seriously in earnest, and on account of serious interruptions that even a few days' absence may make in technical work, the Technology, Athletic, Football and Base Ball Teams have seldom appeared to good advantage. But in track athletics and other lines where individual effort tells the Institute has had a gratifying success.

EXPENSES COVERING TUITION, ETC.

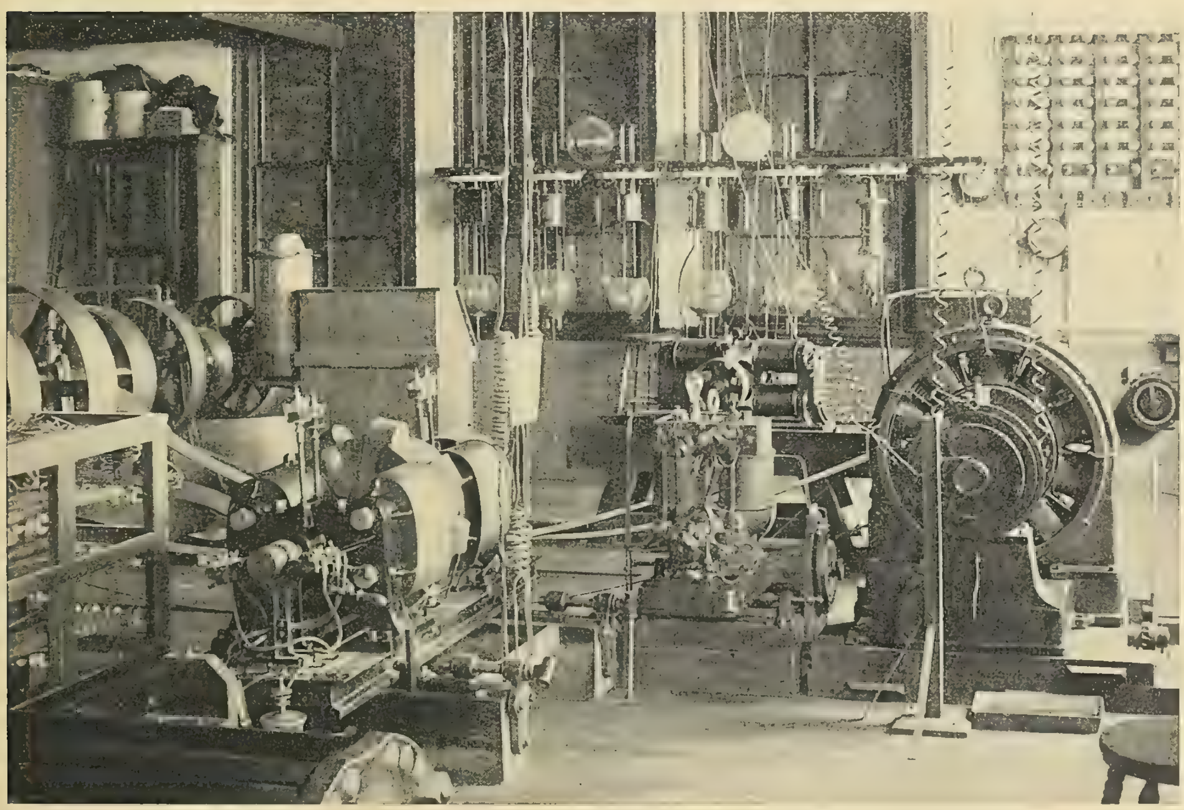
The tuition fee for regular students at the Institute is $200 a year. payable in advance. Special students in general pay the full fee, but under certain circumstances a reduction is made. There are a number of scholarships open to students. Each student on entering the school is required to file a bond for $200 with the Bursar, as security for the payment of all charges against him. The cost of books, drawing instruments, paper and other necessaries averages $30 a year.

Outside of the school expenses, the cost of board and lodging for a student, in the city or suburbs of Boston, need not exceed $7 or $8 a week.

The Institute has no dormitories and does not attempt to control students out of school hours. Many naturally live at home, and others find convenient boarding places near at hand. Some societies have chapter houses where their members may reside. The



ASSEMBLAGE OF RESISTANCE COILS IN THE ELECTRICAL DEPARTMENT.



SPECIAL ELECTRICAL LABORATORY FOR EXPERIMENTAL PURPOSES.

advisability of such a residence depends naturally upon the individual and on the tone of the society.

STUDENT BODY AND FACULTY.

The Institute is a Massachusetts or even a Boston institution, and naturally draws a large proportion of its students from the city and its suburbs, and the majority is always resident in the State, but students are drawn from all the States and Territories, and many come from foreign countries, including the United Kingdom, Canada, South America, Turkey and Japan. The minimum age of admission is set at seventeen years (nearest birthday), but the average age of admission is eighteen. Even when a young man is prepared at an early age he seldom is sufficiently mature earlier to get the full benefit from a technical course.

Since the first class was graduated in 1868 and the earlier classes were all small, the bulk of the alumni is as yet composed of comparatively young men, with their fortunes to make. As a rule an institute graduate may expect immediate employment at living wages, and may make for himself as large a plane as he can occupy. Young men in their impatient natures usually forget that few men attain and fewer can carry large responsibilitity before they are thirty or thirty-five years old.

The course in Naval Architecture is in charge of Prof. C. H. Peabody, who was graduated in 1877, was made a member of the faculty in 1884 and has since developed the work in Steam Engineering, Marine Engineering and Naval Architecture at the Institute. He is the author of "The Thermodynamics of the Steam Engine," of "Tables of the Properties of Saturated Steam," of "Valvegears for the Steam Engine," and (with Professor Miller) of "Steam Boilers."

The faculty is composed with few exceptions (among whom are Dr. Runkle, one of the founders of the school) of men in the prime of life; a considerable proportion, especially among the younger professors, are graduates of the school, whose training has been broadened by foreign travel and study, by experience in practice and by service as teachers. The prominent qualities (as with all technical men) are a capacity for work, an enthusiasm in that work and an absolute loyalty to the school and the work which forbids cliques and shirking. The faculty includes such men as Professor Richards, formerly President of the Society of Mining Engineers; Professor Cross, an acknowledged authority on electricity, especially the telephone; Professor Lanza, whose tests on timber and other investigations on strength of material have formed the basis of much of the modern practices of engineers; Professor Swain, a member of the Subway Commission, and Professor Dewey economist and statistician. The Institute has been specially fortunate in its presidents, beginning with Professor Rogers, who was followed by Dr. Runkle, one of the founders, and later by General Francis A. Walker, who was known as a soldier, economist and educator, and now by Professor Crafts, known by all chemists for his original investigations, and who, aside from these special scientific achievements, has a wonderful grasp of the work and needs of the many and various lines of technical instruction and investigation carried on at the Institute.

AN ACCOUNT OF THE MARCONI SYSTEM OF WIRELESS TELEGRAPHY.

BY CECIL P. POOLE, E. E.

The widespread interest created in marine circles by Signor Marconi's developments in wireless, or rather etherical, telegraphy, is due, of course, to the need for some system of communication between offshore points and the mainland which shall be simpler, more reliable, more flexible and less easily disarranged by extraneous influences than is the existing submarine cable and its apparatus. The application of Marconi's system within the limits of this special field of work is undoubtedly important and its advantages many. The wild claims of unlimited possibilities, however, made for Marconi's system by irresponsible publications are absurd and quite in keeping with the usual newspaper prophecies concerning scientific developments. Controlling ships at a distance, signaling across the Atlantic, displacing the land lines and similar impractical feats have been included as within the alleged scope of space telegraphy. A moment's consideration of the underlying principle of the system will suffice to expose the fallacy of such hasty prognostications.

If an electric current be sent through a wire, magnetic lines of force are set up concentric to the wire, as indicated by Fig. 1. These lines have no specific limit, but the lines farthest from the wire are weaker than those near it because their path is longer. With a steady current the lines remain unchanged, but with a varying current the circles enlarge and contract as the current increases and decreases. If an alternating current be sent through the wire, the magnetic circles expand and contract with each impulse of current, reversing their direction around the wire (not their projection into space) with each reversal of the current flowing in it. Now, if another wire be set up parallel with the current-carrying wire, an electromotive force, alternating in polarity, will be induced in it by the expansion and contraction of the magnetic circles set up around the first wire, the magnetic lines or waves impinging upon the second wire or being "cut" by it. This is roughly what happens in the Marconi system.

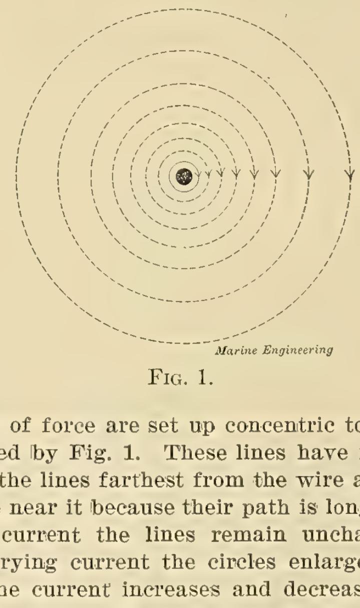


FIG. 1.

A vertical wire is supplied with rapidly recurring charges of electricity by an induction coil, and correspondingly rapid magnetic oscillations are set up which progress into space perpendicularly to the vertical wire, or substantially so. These waves or oscillations impinge upon a distant vertical wire and induce a current flow in it. The current is so feeble, however, and the oscillations are so rapid that ordinary apparatus will not respond to the induced current, hence a device known as a coherer is used for this purpose.

A closed circuit is not employed at either end, because equal lengths of the circuit would be substantially parallel and the waves propagated in each would almost entirely neutralize those in the other. Instead, the vertical wire is charged electrostatically (condenser fashion), the relief of the electrical stress between the upper end of the wire and the earth being crudely represented in Fig. 2 by lines streaming between the two extremes. The induction coil and other apparatus are located as at *A*. The magnetic circles

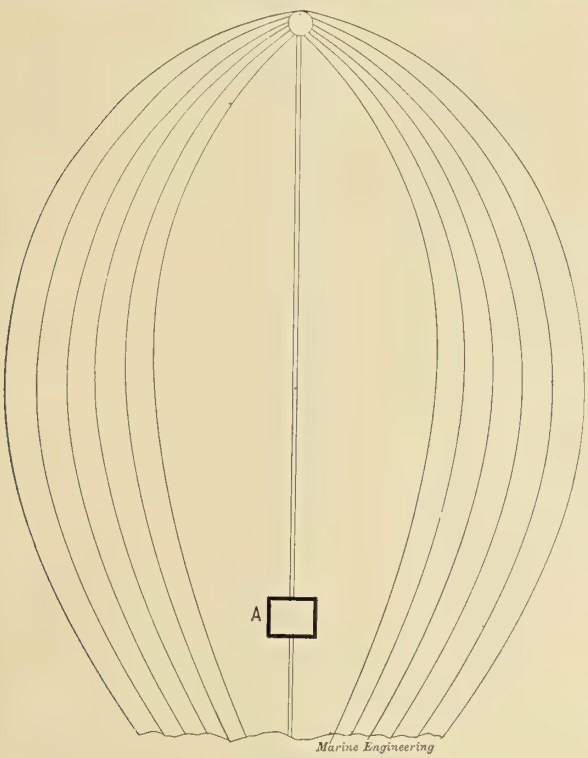


Fig. 2.

or waves may be considered as being created in planes or "layers" at right angles to the "sending wire," or projecting out into space in straight lines from the points of propagation. These waves, lines, or whatever one chooses to call them, are susceptible to reflection, somewhat like light rays, and, consequently, are liable to disturbance or deflection by intervening bright surfaces. Their magnetic character renders them also liable to disturbance by large intervening masses connected with the earth, such as iron buildings, mountains, etc.

Moreover, they are obviously not possessed of volition and cannot turn corners, climb hills, skip along the surface of the earth or sea, or perform any similar antics which they would need to do to possess the wonderful attributes ascribed to them in many quarters. It is plain, from the foregoing, that the transmission of signals by these waves is limited by topographical and physical conditions to a certain degree; if an obstruction, such as a hill or the curvature of the earth, intervene between the points of communication, the vertical wires at each end must be of such a height as to afford an unobstructed path between a considerable length of their upper portions. Hence the impossibility of signaling across the ocean with the present system.

Another drawback to the system thus far is the general accessibility of the transmitted waves. Any receiving station within the radius of range will be affected by the signals, unless a reflector be used at the transmitter and a similar one at the receiver. But where reflectors are used the vertical conductors necessary to long-distance signaling are eliminated, so that privacy is secured only at the sacrifice of the principal *desideratum*, linear range of action.

Notwithstanding the inability thus far to combine the two most desirable features, the system is capable of very great benefit to marine signaling, as instanced by the installation at the South Foreland lighthouse, off the British coast. Here signals sent to the French coast affect the instruments on the Goodwin lightship, but this is not objectionable, because each station has a specific "call," just as telegraph offices along land lines do, and unless one is "called" first no attention is paid to the signals. It is doubtless in this realm of coast signaling that wireless telegraphy will prove most valuable. There is no particular reason why Signor Marconi's apparatus should not supply the requirements of such service.

The apparatus for general signaling (as distinguished from the reflected or restricted waves) is simple to crudity. The transmitting apparatus comprises an induction coil, a battery, a signaling key, two discharge balls and a vertical conductor. Fig. 3 shows the arrangement semi-diagrammatically. The induction coil, *I*, is an ordinary 10-inch Ruhmkorff coil, with a vibrator, *v*. The battery *B* is made up of ordinary dry cells, a sufficient number being employed to give about 14 volts. One of the discharge knobs *dd* is connected to earth (or water) and the other to the vertical conductor *W*, which preferably terminates in a metallic plate or sphere, but not necessarily.

The receiving apparatus is shown by Fig. 4, where *C* is a "coherer," connected in between the vertical conductor *W* and the earth, as were the discharge knobs in Fig. 3. This coherer serves as a circuit-closer for the local circuit through the relay *R*, battery *B*2, and coils *QQ*, whose function will presently appear. The relay *R* controls a sub-circuit comprising a register or sounder *S*, its battery *b* and a vibrator *V*, the latter being connected in multiple with the sounder *S*. The sounder and vibrator are "shunted" by non-inductive resistances *ss*.

The coherer is a glass tube, about 1-4 in. dia. and 1 1-2 in. long, with two metal stoppers, between which is a quantity of silver and nickel filings. These filings ordinarily offer a very high electrical resistance, so that normally the battery current cannot get across in appreciable volume, and the telegraph instruments lie idle. When the key *K* at the sending end is closed the induction coil operates to charge the vertical wire *W* and its terminal with rapidly alternating charges, each discharging across the gap from *d* to *d*. These charges or oscillations propagate waves which set up a corresponding action in the vertical wire *W* at the receiving instrument, as previously explained. The passage of the discharges through the coherer *C* causes its contents to cohere, greatly reducing the electrical resistance between its terminals, so that current from the battery *B*2 can flow and energize the relay *R*, which in turn actuates the sounder *S* and the tapper *V*. This tapper or vibrator simply serves to jar the particles within the coherer and cause them to separate when the oscillations up and down the vertical wire *W* cease. As a matter of fact it separates the coherer particles while current is passing, but they cohere again between the blows, and although the circuit of the relay is broken and closed by this action a great many times per second, the sounder *S* is not affected because of the inertia of its lever and the time constant of its magnets, which unite to prevent the

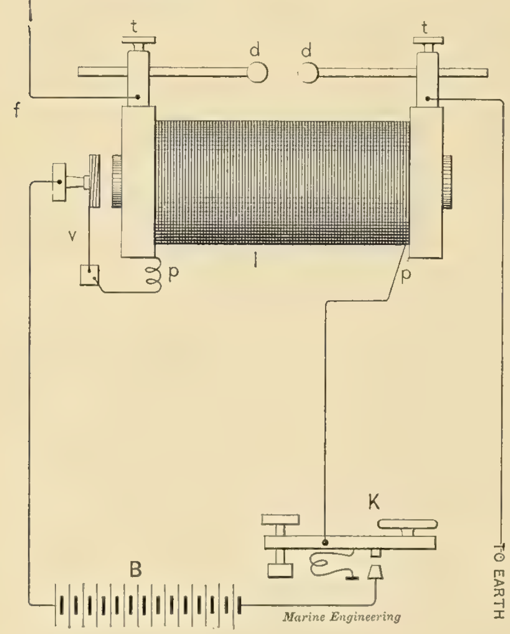


Fig. 3.

lever from following the rapid flutterings of the relay lever. A more positive relief from possible disturbance due to the effect of the tapper upon the relay circuit would be afforded by the use of a polarized sounder or register, affected only by current reversals and not by making and breaking its circuit.

The coils *QQ* are highly inductive, but of low resistance, so that they do not impede the relay current greatly, but serve to "choke" back the oscillating currents discharged by the wire *W* and force them to travel through the coherer instead of allowing them to be wasted in the relay circuit, where they would be inoperative because of their small volume and alternating polarity. The shunts *sss* are used to prevent sparking at the various contacts by reason of the self-induction of the magnets, and also to prevent the exertion of disturbing inductive effects upon the coherer, which, it will be remembered, is extraordinarily sensitive.

When the signals are to be made selective, the coherer is mounted in front of a reflector, as shown in Fig. 5, which restricts its responsiveness to those waves that approach from in front. The vertical wire is taken off, as its presence would, of course, render the reflector at the coherer useless. The coherer is further supplied with "syntonizing" strips of copper *cc*, which must be of such length that their natural rate of vibration is in accord with the frequency of the oscillations to be received. This necessity for fine adjustment constitutes a serious drawback to the use of the selective system. With an ordinary induction coil, several things affect the "frequency." A slight variation in battery strength, change of temperature in the vibrator tongue or a touch of the contact screw may throw it out of syntony with the receiver. When a reflector is used behind the coherer, a similar one is used behind

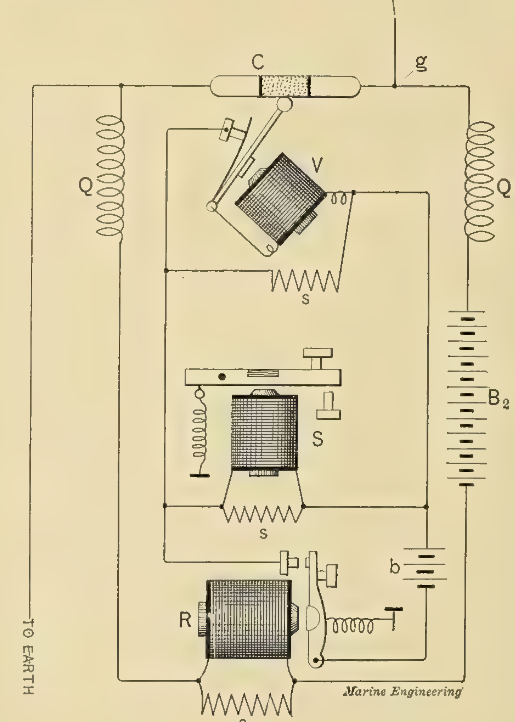


Fig. 4.

the discharge knobs of the induction coil at the sending end, as shown by Fig. 6, and two auxiliary spheres are used to give three discharge gaps instead of one. The vertical wire and earth connection are omitted here also for the reason given before.

Of course each station must have both signaling and receiving apparatus, but only one vertical wire is necessary. The sending and receiving instruments

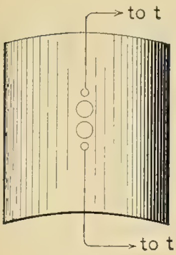


Fig. 6.

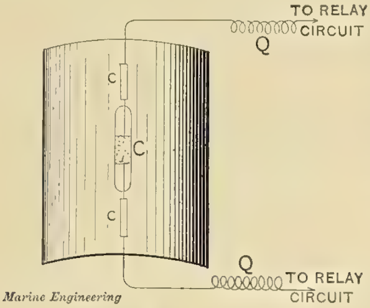


Fig. 5.

are not connected to the vertical wire simultaneously, however. Referring to Figs. 3 and 4, the letters *f* and *g* indicate points at which the connections are changed. A switch is provided which, when thrown one way, connects the vertical wire to the transmitting apparatus at *f*, Fig. 3, and when thrown the other way breaks this connection and transfers the vertical wire to the coherer circuit at *g*, Fig. 4. The coherer is enclosed in an iron box, so that its proximity to the induction coil will not result in serious disarrangement when the operator is sending signals. One immense advantage of the vertical wire system is the ability to locate the instruments in any convenient spot. With the reflector system the instruments must not be shielded by objects which act as reflectors to the waves.

The applicability of the Marconi system to marine signaling is obvious. Lighthouses and vessel masts lend themselves peculiarly to the installation of the apparatus by affording an ideal location for the vertical wires, and once these are established the arrangement of the instruments is a simple matter. The practical advantages of the system will be evident to those interested. Ships can signal to each other and to shore stations over distances of 5 to 15 miles, according to the height of their masts and communication between lightships and shore stations can be maintained regardless of climatic conditions. The system is not affected by weather, temperature, light or darkness, which of course immensely enhances its value as a means of communication in exigencies. Moreover, no peculiar skill is necessary to the manipulation of the vertical wire system, any intelligent person being capable of learning to handle the apparatus in a short time. An inherent disadvantage is the inability to transmit more than one set of waves simultaneously within a given range, so that during fleet evolutions only one vessel can signal at a time. For the mercantile marine the advantages of such a means of communication, as for example, vessels passing at sea, or approaching land in a fog, are so great that should further experiment place the system on a practical workaday basis, its adoption will doubtless be widespread and immediate.

RECENT FULL POWER TRIAL OF THE U. S. BATTLESHIP MASSACHUSETTS.

The battleship *Massachusetts*, with the other ships comprising Admiral Sampson's squadron, underwent a four-hour trial run recently, on the way from St. Pierre, Martinique, to San Juan, Porto Rico. The first two hours were under natural draught and the last two with forced draught. As the *Texas* and *Indiana* participated in the trial, an unofficial race took place and it is reasonable to suppose that every ship was doing its best. Under these conditions therefore it is interesting to compare certain data taken from the official log of the builders' trial of the *Massachusetts* with similar data taken during this run.

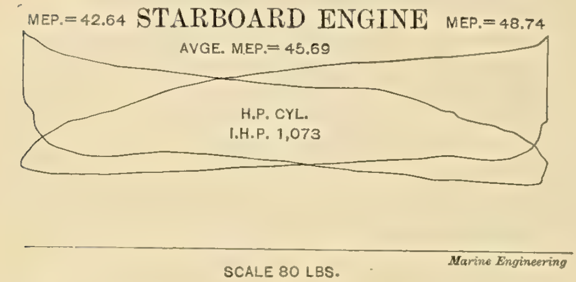
Three years have elapsed since Cramps drove her for four hours at a speed of 16.75 knots and developed 10,127.83 horse power. During that period the *Massachusetts* has performed the usual routine work of ships on the home station besides taking part in the Cuban operations. Since then her stacks have been lengthened 10 ft. and her draught greatly improved thereby. Bilge keels have been fitted also, about two-thirds of her length. With these two exceptions she is practically the same ship as the Cramps turned over to the Navy Department in June, 1896.

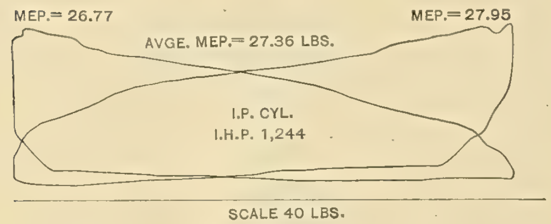
The accompanying data taken during the four-hour run, while not official, were taken by a member of the engine room staff and can be relied on as accurate. All boilers were in use, including the two auxiliary or donkey boilers. The latter were used to supply steam for all the auxiliary engines, such as dynamo, blowers and feed pumps. The main boilers were under natural draught from 7.10 A. M. to 9.10 A. M. and under .75 in. of air pressure from 9.10 A. M. to 11.10 A. M., when the trial ended. The maximum I. H. P. developed during the run was 7,700. In comparing the run with Cramps' trial, it would be well to take into consideration the different conditions prevailing. The official trial took place in the month of April off the Massachusetts coast, while the last run was made in tropical waters. The temperature of the fire rooms was high, and showed a difference of 59 deg. over that registered during the official trial, and there was also a temperature difference in the injection water of 37 deg., as will be noticed on inspection of the accompanying data. The run in every way was a complete success. The engines worked smoothly, and the boilers stood the strain of two hours' forced draught without showing any signs of weakness. A set of cards for each engine is printed on the next page.

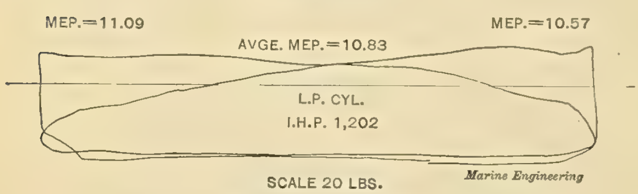
Each ship of the five taking part had thirty minutes start of the next one following. The battleship *Indiana* got away first, followed by the battleships *Massachusetts*, *Texas*, and the anchored cruisers *Brooklyn* and *New York*. The *Massachusetts* overhauled the *Indiana*, left the *Texas* out of sight and was two miles ahead of the *New York* when her four hours were finished. The *New York* overhauled and passed the *Brooklyn*, while the surprise of the day was the manner in which the *Indiana* left the *Texas* behind.

The *Massachusetts* is classed as a seagoing coastline battleship and is equipped with two 13 in. and four 8 in. barbette turrets. She is 348 ft. long on the load water line, 69 ft. 3 in. extreme beam, and has a draught of 24 ft. on a displacement of 10,288 tons.

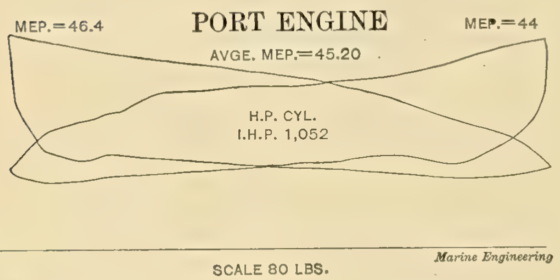
U. S. S. Massachusetts Under Forced Draft.

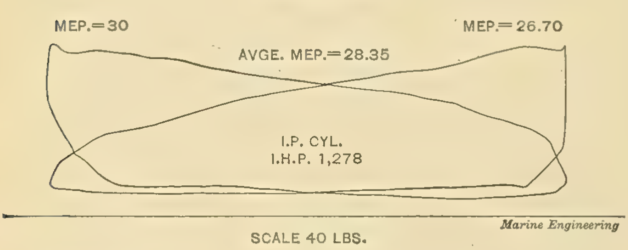


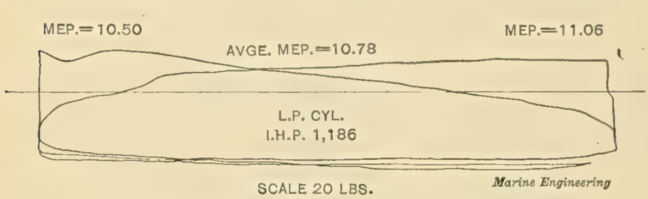




STARBOARD ENGINE. TOTAL I. H. P. 3,519.







PORT ENGINE. TOTAL I. H. P. 3,516.

Her normal coal supply is 400 tons and her total bunker capacity is 1,597 tons.

U. S. S. *MASSACHUSETTS'* COMPARATIVE LOG OF OFFICIAL TRIAL AND FOUR HOUR TRIAL RUN (3 YEAR INTERVAL BETWEEN TRIALS).

Engines.	Time of trial.	Engine revolutions per minute.	Steam pressure, in pounds per square inch. In boilers, above the atmosphere.	At engines, above the atmosphere.	In receiver above a perfect vacuum. 1st.	2d.	Steam cut-off, in decimals of the stroke, from the beginning. H. P. Cyl.	I. P. Cyl.	L. P. Cyl.	Opening of throttle valve, in tenths.	Vacuum in condenser, in inches of mercury.	Pounds of coal consumed per hour.	Temperature, in degrees Fahrenheit. Engine room.	Fire room.	Injection water.	Discharge water.	Feed water.	Revolutions or double strokes per minute. Air pump.	Circulating pump.	Speed knots.
Stbd.	Official trial, 1896	132.30	163	156.6	80.1	28.05	.673	.678	.706	Wide	25.15		75.1	96.43	43.5	118.2	114.4	15	159	16.75
Port.		133.06			74.7	27.9	.673	.694	.712	Wide	25.20		71.7	96.43	43.5	122.9	113.1	18	195	
Stbd.	Two hour natural draft, 1899	110.12	151.5	148.5	51	20.2	.690	.678	.704	1.05	24	15,800	102	140	80	119.7	112.25	18	140	14.7
Port.		108.12			50	22.5	.717	.694	.706	1.15	24.5		102	140	80	121.5	125	18	145	
Stbd.	Two hour forced draft, 1899	116.46	156.5	152.5	62	24	.690	.678	.704	2.25	23.96	17,650	102.5	155.7	80	132	123	20	160	15.3
Port.		117.9	156.5	152.5	62.5	23	.717	.694	.706	2.30	26		106.5	155.7	80	123.7	123	27.5	159	

Cramp's official I. H. P.: S., 5,049.95; P., 5,077.88. Total I. H. P., 10,127.83. Maximum I. H. P. during 2 hours' forced draft, 7,700. Average speed for 4 hours, 15 knots.

CONSIDERATION OF THE INDICATOR AND ITS USES ON BOARD SHIP—IV.*

BY R. W. JACK.

To find any other point on the curve between the points already obtained, say when the crank arm makes an angle of 45 degrees with the center line of engines on either side of its mid position, it becomes necessary to compare the acceleration produced during the 45th degree, and this we find by comparing the mean velocities during two consecutive degrees, viz., the 44th and 45th. The mean velocity during the 44th degree in the first quadrant is equal to the distance traveled by the piston during such degree. Let d_1, d_2 and d_3 be the distances moved by the piston from rest at the end of the 43d, 44th and 45th degrees, and y_1, y_2 and y_3 the angles which the connecting rod makes at these points with the line of centers. The mean velocity of the 44th degree is

$$d_2 - d_1 = [\,(\text{vers } 45°) + (4 \text{ vers } y_2)\,] - [\text{vers } 440 + (4 \text{ vers } y_1)\,]$$

During the 45th degree we have

$$d_3 - d_2 = [\,(\text{vers } 46° + (4 \text{ vers } y_3)\,] - [\text{vers } 45° + (4 \text{ vers } y_2)\,]$$

To find the angle y and its versed sine we make use of the table of natural sines, etc. In the right angled triangles (Fig. 12) $B\ C\ D$ and $A\ C\ D$ where $C\ D$ is the common perpendicular

$$\sin y : \sin x :: \text{crank } A\ D : \text{con. rod } B\ D, \therefore \sin y = \frac{\sin x \times A\ D}{B\ D}\ \sin y = \frac{\sin 45 \times 1}{4} = \frac{.7071068 \times 1}{4} = .1767767,$$

the angle corresponding to which is 10° 11′ (approximate) and the vers is = .0157490. The versed sides of angles 44°, 45° and 46° are respectively .2806602, .2928932 and .3053416, and the angles y_1, y_2 and y_3 of the connecting rod corresponding to the angles 44°, 45° and 46° of the crank are approximately 10°, 10° 11′, and 10° 22′, the versed sines of which are—.0151951, .0157490 and .0163032. The mean velocity of the piston, or the distances it has traveled during the 44th degree of the crank, is therefore

$$d_2 - d_1 = [.2928932 + (4 \times .0157490)\,] - [.2806602 + (4 \times .0151951)\,]$$
$$\text{“} \quad = .3558892 - .3414406 = .0144486 \text{ ft.}$$

The mean velocity during the 45th degree is

$$d_3 - d_2 = [.3053416 + (4 \times .0163032)\,] - [.2928932 + (4 \times .0157490)\,]$$
$$\text{“} \quad = .3705544 - .3558892 = .0146652 \text{ ft.}$$

The difference of the mean velocities during the 14th and 45th degrees is therefore

$$.0146652 - .0144486 = .0002166 \text{ ft}$$

This, then, represents the acceleration imparted, or the increase in the mean velocities during the 45th degree in the first quadrant of the crank pin circle.

We have found the forces in pounds per square inch of piston area required to communicate to the piston its initial velocity at both extremities, that is the accelerating force on the one side and the retarding force on the other. In the example we are now considering we have found them to be respectively 38.1 lb. and 22.8 lb. per square inch. We have also stated that the distances traveled by the piston during the first and last degrees of the down stroke of the crank are .0001904 ft. and .0001442 ft. Taking the former for comparison, and assuming the piston to fall this distance from rest, the mean velocity is again represented by this distance; but in the case of a body falling from rest the terminal velocity is twice the mean velocity, i. e., if v be the terminal velocity, V the initial velocity, and x the mean, then

$$x = \frac{V + v}{2} \text{ and as V.} = o,\ x = \frac{v}{2} \text{ or } v = 2\,x.$$

The terminal velocity is therefore, at the end of the first degree .0001904 × 2 = .0003808 ft. per second, and the acceleration during this interval is equal to the difference of velocities, thus, .000380 — o = .0003808 ft., because the piston has moved from rest. An acquired acceleration of .0003808 ft. per second is represented by a force of 38.1 lb. per square inch of the piston area, and as forces are proportional to the acceleration produced in a given time the force required during the 45th degree is

$$.0003808 : .0002166 :: 38.1 : x; \therefore x = 21.6 \text{ lb. per sq. in.}$$

To find the force exerted by the crank pin in arresting the velocity of the piston, etc., at an angle of 45° of the crank with the line of centers in the second quadrant, we proceed in the same way. If as before d_1, d_2 and d_3 represent the total distances of the piston from the bottom end of its stroke at angle of 44°, 45° and 46° of the crank with center line of engines, then the mean velocity or distance traveled during the 44 degrees is

$$d_2 - d_1 = [\text{vers } 45° - (4 \text{ vers } y_2)\,] - [\text{vers } 44° - (4 \text{ vers } y_1)\,]$$
$$\text{“} \quad = [\,2928932 - (4 \times .0157490)\,] - [.2806602 - (4 \times .0151951)\,]$$
$$\text{“} \quad = .2298972 - .2198798 = .0100174.$$

During the 45th degree the mean velocity is

$$d_3 - d_2 = [\text{vers } 46° - (4 \text{ vers } y_3)\,] - [\text{vers } 45° - (4 \text{ vers } y_2)\,]$$
$$\text{“} \quad = [.3053416 - (4 \times .0163032)\,] - [\,.2928932 - (4 \times .0157490)\,]$$
$$\text{“} \quad = .2401288 - .2298972 = .0102316.$$

The retardation at this point on the down stroke is again proportional to the difference of velocities, i. e., .0102316 — .0100174 — .0002142, and stating it as before in comparison with the initial force and acceleration, we have

$$.0003808 : .0002142 :: 38.1 : x.$$
$$\therefore x = 38.1 \times \frac{.0002142}{.0003808} = 21.4 \text{ lb. per sq. in.}$$

We thus have mathematically located five points on the curve, viz., 38.1 lb. at the beginning, 21.6 lb. at 45° in first quadrant, zero on the back pressure line 1.476″ from center, 21.4 lb. at 45° in the second quadrant, and 22.87 lb. at the end of the down stroke. Those points should be marked off from the base or line of counter pressure to the same scale as that of the real diagram and at a distance from either extremity of the indicator card equal to that found by the formula,

$$d = \text{vers } x + (4 \text{ vers } y) \text{ or } d_1 = \text{vers } x - (4 \text{ vers } y)$$

where d is the total distance from the top end, and d_1 is the distance from the bottom.

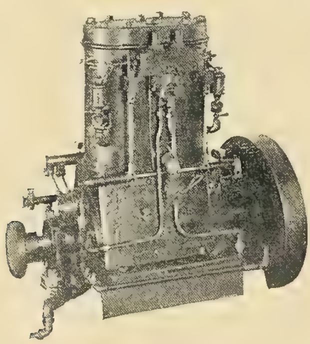
In our present example the only angles taken were 45 degrees in each quadrant, d was found to be .3558892 feet, and d_1 .2298972 ft. It only remains to draw the curve.

*From a paper read before the Institution of Engineers and Shipbuilders at Hong Kong.

IMPROVED APPARATUS.

Sarvent Marine Gasoline Engine.

The accompanying cut shows a Sarvent Marine four cycle gasoline engine which the makers claim to be superior to and more reliable than any built on the two cycle system. They are built with one, two, three or four cylinders. The design is neat, compact and simple. The cylinders are entirely enclosed by one water jacket, which connects with the water jacket in the head. The base is entirely enclosed and contains oil and water in which the cranks slush, thus making all interior mechanism and crank bearings self-lubricating. The piston is so constructed as to always carry oil that is slushed into it by the crank from the base, and thus it lubricates the cylinder at every point of the stroke. The circulating water is discharged from the head through a special port and out through the exhaust pipe, keeping the pipe always cool. The exhaust is carried directly under water,

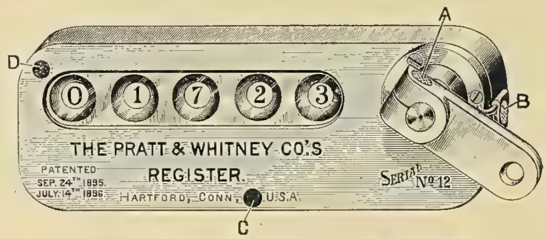


SARVENT MARINE ENGINE.

without the use of a muffler of any kind, thus preventing objectionable noise and odors. The compactness of this engine peculiarly adapts it for auxiliary work in sailing vessels. The engine works under low compression, thus reducing vibration and permitting the use of a lighter fly-wheel and the running of engine at a lower speed. The speed of the engine is controlled by throttling the air valve, which, for convenience sake, may be located in the bow of the boat near the steering wheel. The gasoline tank is placed in the bow of the boat, underneath the forward deck. A pump is provided to keep a constant supply of oil in a small siphon cup located directly under the induction valve and provided with an overflow pipe, which prevents flooding. The overflow returns into the main feed pipe back of the check valve. Air and gasoline meet in the siphon chamber; the mixture is instantly vaporized and the vapor then passes into the cylinder in an even charge. The igniter is what the makers term a snap-break contact, with platinum contact points. The points are so arranged that the charge passes over them on its way to the cylinder, keeping them cool and preventing oxidation. It is provided with an early and late trip. In starting the trip is thrown out, causing the explosion to take place after the piston passes over the center on the downward stroke, and thus avoiding any backward kick of the fly-wheel. The mode of ignition is claimed to be one of the principal advantages of this engine. It is manufactured by the Sarvent-Crider Marine Engine Co., 105 West Monroe street, Chicago, Ill.

Revolution Counter.

A neat and very compact form of engine revolution counter is shown in the accompanying engraving. This counter has five dials; the first dial has a duplex driving mechanism which is one of the important

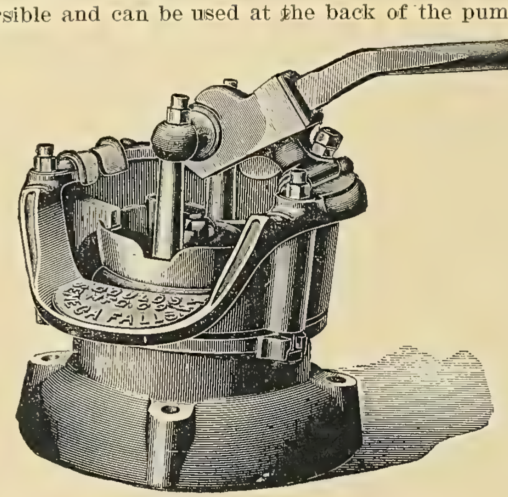


PRATT & WHITNEY REVOLUTION COUNTER.

features, comprising a pawl and ratchet dial actuator, also an escapement driving device working in unison with the ratchet device. The result is absolute certainty of action. The escapement is of such a character that it not only serves to limit the movements of the other parts—so there can be no overthrow—but, should the pawl fail to act, it performs for the time the entire work of operating the dials. The counter is of special interest as an instrument of precision. It is manufactured on the "interchangeable system," by a plant constructed especially for it, and made by the most approved methods of watch-tool manufacture. The working parts are contained within a plain but neat and substantial case—positively excluding all dust and protecting the works against all ordinary accidents. The Counter is manufactured and sold by The Pratt and Whitney Co., Hartford, Conn., U. S. A.

Diaphragm Suction Pump.

An improved form of diaphragm pump is shown in the engraving printed herewith. The lever is reversible and can be used at the back of the pump or

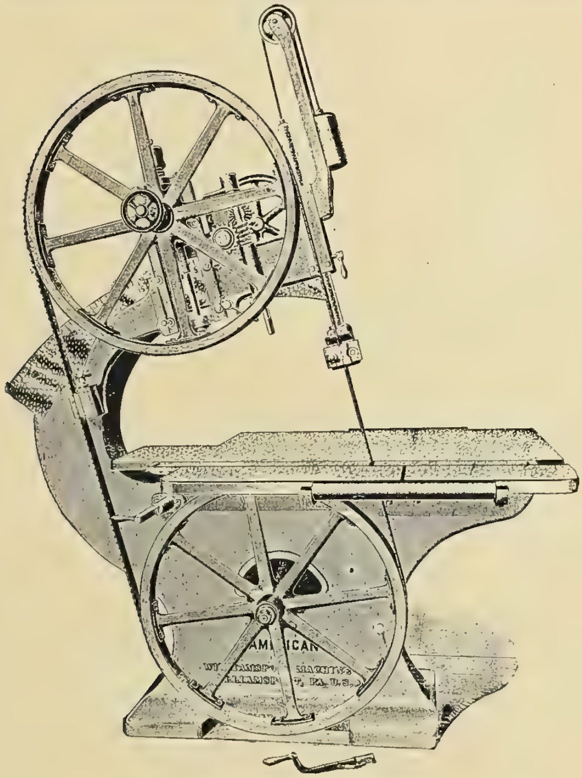


GOULD DIAPHRAGM PUMP.

on either side. The lower valve is made of metal, rubber faced, and is easy of access and readily removable. The waterways are large and easy. First-class materials alone are used in the construction; the diaphragm, which takes the place of a plunger, being of selected rubber. Pumps of this pattern are particularly adapted for pumping water containing mud, sand, gravel, sewage, coal, chips or any semi-fluid matter. They are fitted with bottom suction for use in places where they can remain stationary, as on vessels, barges, dredges, wharves. Pumps of similar pattern are built with side connection for hose or pipe. The capacity of the pump shown is about 3,000 gallons an hour, the pump having a 12 1-2 in. diaphragm and 3-in. suction pipe. These pumps are manufactured by The Goulds Manufacturing Co., Seneca Falls, N. Y.

Adjustable Bevel Band Saw.

The accompanying engraving illustrates a new adjustable bevel band saw just introduced by the American Wood Working Machine Co., and built at their Williamsport Machine Co. factory at Williamsport, Penn. This machine is intended for all classes of band sawing where heavy stock is to be sawed beveling, and is specially adapted to the uses of shipyards. The main frame is very heavy and rigid, having cored sections, and is cast in one solid piece. Wheels are 40-in. dia. and 2 1-2-in. face, with wood rims built up of cants turned off true, covered with rubber and perfectly balanced. Hub and spokes are cast in one piece, to which the wood rims are securely bolted, making the best wheel that can be made. The spokes cannot get loose, as is often the case where the spokes are made separate and fitted into the hub.

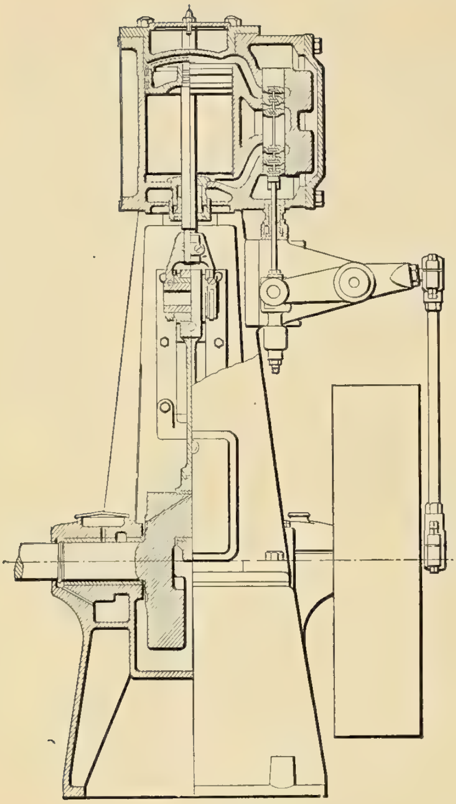


BAND SAW FOR SHIPWORK.

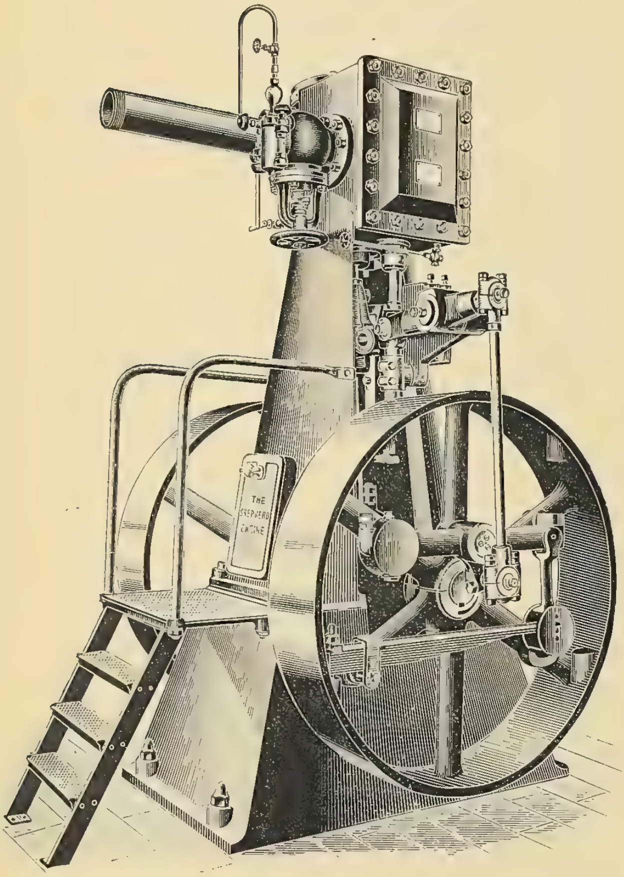
The top wheel can be adjusted to saw from square to an angle of 45 deg., either by means of the crank shown at the base of the machine, or by a hand wheel at the opposite side; and both top and bottom wheels are adjustable for tracking the saw on the wheels. The upper guide is fitted with a steel roller for the back of the saw to bear against, and has hard maple guides to run against the face of the saw. The table is iron, and is provided with an iron roller at front and rear for relieving friction on the table when sawing heavy stock. Adjustable iron plates are fitted into the table to close the opening when saw is adjusted. The shafts are very heavy and run in long bearings lined with good babbitt metal, and the lower shaft is provided with a bearing outside of the tight and loose pulleys. The machine will receive lumber up to 17 in. thick and will carry saws up to 2 1-2 in. wide. Further information can be had upon application to any of the branch offices of the company, or to the New York headquarters, 80 Liberty street.

Shepherd Automatic Engine.

The Shepherd Vertical Automatic Engine was designed with a special view to direct connection to electric generators and other fast running machinery, such as fans, pumps, blowers, etc. It combines, with simplicity of construction and symmetry of form, the greatest degree of rigidity and strength. While representing concentrated power in the minimum space, convenience and accessibility to the working parts have not been sacrificed in obtaining compactness, nor has simplicity been gained at a loss of efficiency. The Shepherd engine is compact in the sense of being convenient and easy of access without any waste of space, and at the same time rigid and self-contained. It is simple in that it consists of but few parts, and all wearing surfaces are provided with the most accurate adjustment for taking up wear. The simplicity, the high speed at which it is capable of being run, the general good design and liberal wearing surfaces, and the very small space a given power occupies, make this engine particularly desirable for driving direct-connected generators for lighting on steamships, yachts and ferry boats, as well as for power or lighting purposes at wharves, docks or other isolated stations. The engine is clean and neat in operation; not a drop of oil need be thrown about on the engine-room floor or walls. The bed and frames are of cast-iron, well ribbed and braced, and within them are contained the cross-head guides, the main bearings and the valve gear support, thus making it impossible for the working parts to get out of line, except for wear, and adjustment for this is provided. The back frame contains the guides and the rocker-arm bracket, and it supports the cylinder when the front frame is removed to take out the crank-shaft, if need be. The cylinder and steam chest are cast together. The cylinder barrel and both top and bottom heads are jacketed with an air space or some non-conducting material. The valve is double ported for both steam and exhaust; and it is self adjusted for steam tightness, thus automatically following up all wear. It is also collapsable and acts as a relief valve in case of water in the cylinder. The governor is of the well-known Shepherd type, which gives remarkable results in the way of close regulation. It combines simplicity with freedom from dirt, no oil being used about it in any way; and there is no noise or pounding even after long use. The crank-



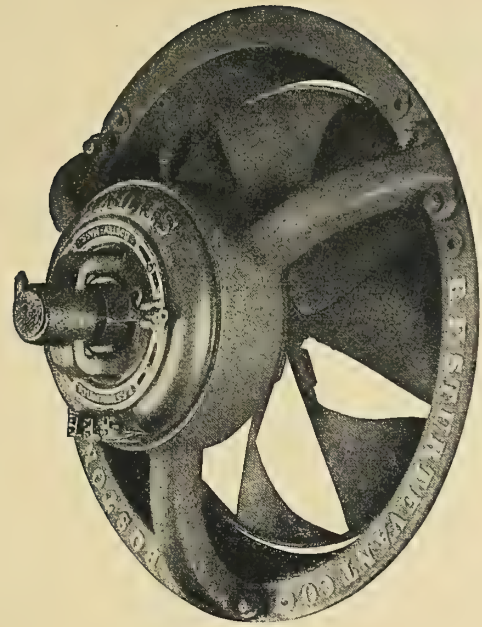
SHEPARD AUTOMATIC ENGINE.



shaft is of solid steel, correctly counterbalanced. The crank pin and main bearings are of very liberal proportions, and they are automatically oiled by means of ring or chain oilers, which keep a continuous stream of oil running over them at all times. The piston rod, connecting rod, valve and eccentric rods, pins, bolts, etc., are all of steel, accurately machined. The cross-head is of phosphor bronze or cast steel. The engine is built by the American Fire Engine Company, Seneca Falls, N. Y., and is made in both simple and compound types; the latter, both cross and tandem styles, being adapted either for belted or for direct connection. Our illustration shows the type covering a range of sizes from 75 to 200 horse power.

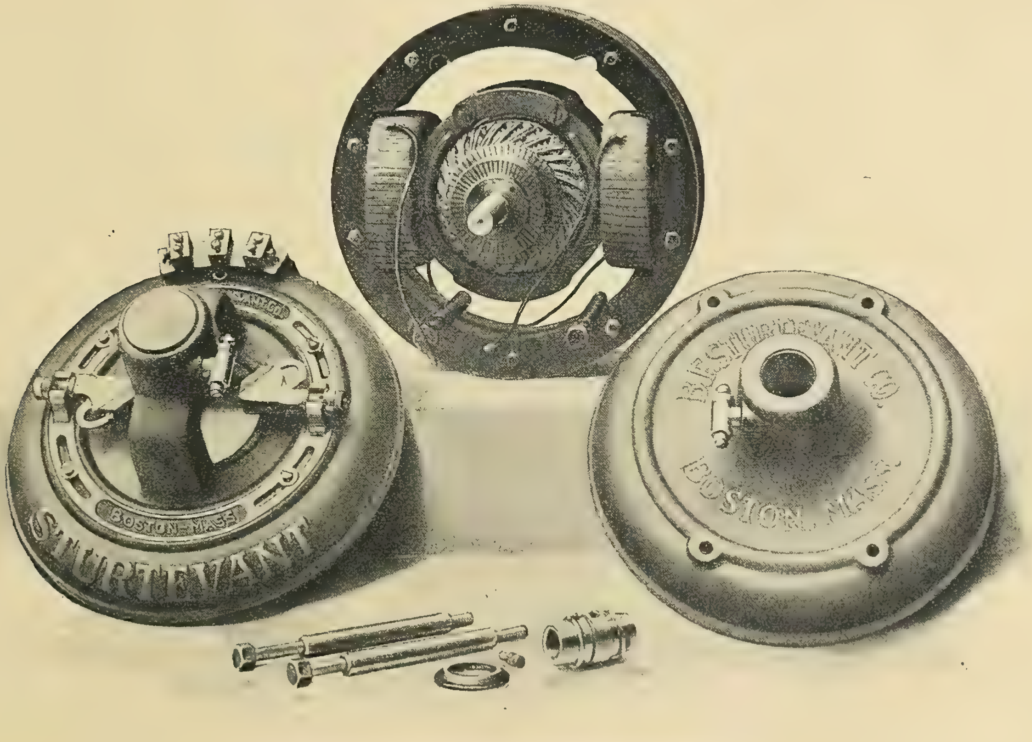
Electric Ventilating Fan.

Although the propeller or wing type of ventilating fan has been equipped with various types of electric motors, the design of these motors has hardly received the attention demanded by the importance of the work performed by such machines. The B. F. Sturtevant Co., of Boston, Mass., has of late been giving the entire subject very thorough investigation, and is now presenting an entirely new type of fan wheel and of direct connected motor, as shown by the accompanying engravings. The wheel has been designed to secure the highest efficiency, and consists, in the size shown in the illustration, of eight blades, secured to a light but stiff hub, and held in their relative positions by a hoop at the periphery. The delivery edge of the fan wheel is helical, so that the air is picked up at the inlet edge at low velocity, and gradually accelerated to its maximum velocity with the least amount of slip. The motor presents specially interesting features, and from the accompanying description it is clear that the design is the result of most careful study. Manifestly to produce a motor having low temperature rise, it is imperative that the efficiency be made as high as possible. Heretofore the name of enclosed motor coupled itself instinctively with high surface temperature of enclosing case, but in the present motor the temperature rise after 10 hours' run is 27 to 30 degrees Fahr., against 60 to 80 degrees Fahr., a figure frequently met with in practice. This low temperature rise has not been obtained by increasing the size or weight above any of the existing types, but by designing the motor to fulfil the following conditions: (1) The production of a magnetic field of the greatest possible quantity in proportion to the rated horse power. (2) The excitation of this field with the least possible consumption of energy. (3) Suitable material for poles to eliminate eddy currents and heat loss therein. (4) Pole pieces of such design as to prevent distortion of magnetic field by armature flux and the consequent low reduction of the self-induction of the armature coils. (5) Arrangement of magnetic circuit such that the leakage is small. (6) An armature in which the core and resistance losses are reduced to a minimum. The first requirement is fulfilled by using soft and highly permeable sheet iron stamped to the required form and assembled to the correct thickness. The use of laminated iron satisfies the demands of small exciting energy and elim-



ELECTRICALLY DRIVEN FAN.

inates eddy currents and heat losses in pole pieces. The shape of the pole pieces shown in the cut imposes so great reluctance to armature flux that it's disturbing effect at full load is negligible, and at the same time lowers the self induction of armature coils by the fact of the pole pieces being saturated. The conditions of small leakage of magnetic flux are met by having the poles, or parts in magnetic circuit, possessing great differences of magnetic potential, of small area and placing the exciting coils as close to the armature as possible. The observed leakage in this machine is less than one-half that of many of the types in use. To reduce the core losses, only the best quality of annealed sheet iron is used, the plate being japanned before assembling on shaft to avoid eddy currents. The resistance and amount of copper on the armature core is, of course, comparatively small, on account of having a magnetic field of great quantity, as before mentioned. By observing the conditions above enumerated in the design of this type of motor, an efficiency of over 80 per cent is obtained at brake, and this in a 1-2 K. W. 500 volt motor running 1,300 R. P. M. The sparking attendant on changes of load has been entirely eliminated, so that a load of 175 per cent of rated capacity of motor may be carried with absolutely no sparking, the position of brushes remaining unchanged. This feature, combined with small temperature rise, allows of temporary overloads being carried with impunity. Referring to the cuts it is observed that the arrangement for supporting the brush holders is a departure from existing methods and gives great rigidity to brush-holders. The leads to the brushes are brought through from the rear, thus doing away with any dangling connecting wires. The brushes are of hard carbon in holders of a modified reaction type that allow of easy adjustment when it becomes necessary to reverse the direction of rotation of the motor. In such a case the field connections are reversed at the terminal block. These motors are built in the two pole type in sizes of from 1-4 to 3 H. P., and in a similar type, but multipolar up to 20 H. P. All of these motors are also built as independent machines, and are particularly convenient for the operation of small machines, tools and the like. The fan wheels with connected motors are constructed in sizes from 18 in. to 120 in.



STURTEVANT PROPELLER TYPE VENTILATING FAN.

MARINE ENGINEERING

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A CAREFULLY prepared comparative statement of the conditions of American shipping and shipbuilding, from Revolutionary times down to the present year, will be found in another part of this issue, together with the author's views of the future. By the aid of graphic illustration, he has stated the case so plainly that at a glance the history of the subject can be read. These tables are of immense interest as showing, unobscurely, not only the past and present position of the country, but also the general trend of what we may term marine affairs. An inspection of the charts will show that, with a single exception, the "peak" condition of American maritime interests was attained at the time of the Civil War, and that since there has been a tremendous "drop," with a recent upward tendency. The exception is the coasting trade, which at the close of 1898 had reached nearly 4,000,000 tons, the greatest amount in any year in our history of navigation. Though it is generally understood that the Civil War was the chief cause of the decline of the American merchant marine, the immediate effect of that war is not so generally realized. This is vividly depicted by the table of "American tonnage sold to foreigners," in which the Civil War period is shown to represent a loss of about 280,000 tons. The energy and capital which were diverted from marine pursuits during that period of strife have, to a considerable extent, remained away. After the war both found an outlet in the development of the West; a development which really, as a display of national energy and enterprise, more than offsets the decadence of shipping interests. Railroads absorbed the mechanical ingenuity of the people, and provided an outlet for speculative capital; and the tremendous number of public works of every description that followed in the train of civilization also gave ample opportunity to engineering science and the mechanic arts. But for this reaching out westward the coal and iron, which now can be laid down at any point with cheapness and despatch, would not be available in the present abundance. Now, however, that this period of exploration is completed and the country is reaching out across the waters, both in trade and sovereignty, the same cry for means of communication goes up that was heard from the Western pioneer. With the men and the material, and the tremendously greater capital available, will not this cry be responded to as adequately on the sea as on land? There are differences in the situation as wide as the differences between the means of communication on land and sea, but there is the same ultimate result—transportation. Chief, of course, among these differences is the question of competition, which on sea is not between one corporation and another of one kind, but among widely different peoples, each striving desperately to hold what they own and get all the benefit of the natural growth in the world's over-sea trade. It is this feature which makes some form of State aid or encouragement a necessity when the weak (as individuals) come into direct competition with the strong. Our author, Geo. R. McDermott, N. A., who comes to the subject equipped with an extensive professional experience on the Clyde and a long study of the conditions in the land of his adoption, advocates a system of bounties. With that clear insight which his former coutrymen are famed for, he looks past the gilded liner and sees in the dingy tramp the real foundation for a merchant marine. It is to this type of vessel, which carries cheaply and well the product of our mills and farms to foreign lands and brings back raw materials, to be in turn reshipped, that we must look for a proper solution of the problem. Another plan of State encouragement is suggested by a writer in the current issue of *The Atlantic Monthly,* and in proposing a remedy for present conditions he says:

The first step in this direction should be the formation of a body similar to the British Board of Trade, or a Department of Merchant Marine like the Department of Agriculture, in order that the interests of shipowners and seamen and all maritime matters may receive particular and constant attention. The head of this department should be a Cabinet officer. He should be chosen to his position by the advice of the chambers of commerce, shipowners and ship masters' associations of the country. The department should have under its control all seaboard consuls, who should be chosen from past officers of the boards of trade, naval officers, and shipmasters, and should hold their office until incapacitated by age. It should inspect, while building, every vessel put together in American yards, performing this service without expense to the owner. Examinations for the positions of master, mate and engineer should be part of its duty. But this is only in the line of general improvement. Something more specific and radical is needed to place the United States on an equal marine footing with England—some measure that will protect and invigorate the industry without being a protective law. To that end, it is suggested that in connection with the department there should be a liberal system of marine insurance. Every ship built under government inspection and engaged in foreign trade should have her hull insured free; the department with the United States Treasury behind it acting as underwriter. And all cargoes carried by oversea routes under the American flag should be insured at a lower rate than that offered by foreign insurance companies.

There are wide and honest differences of opinion as to the best means of resuscitating the merchant marine. With the admitted necessity for action, and the diversity of methods proposed, the most sensible plan, it seems to us, would be the appointment of a Federal commission to make a searching inquiry into all phases of the subject, not only from the shipowners' but the shipbuilders' and shippers' points of view, and to reach a decisive and conclusive opinion in the form of a recommendation for Congressional action. Such a commission should not be a party affair, but should be organized on broad lines, and include in its membership a sufficient number of unbiased experts to outweigh any merely political influences.

IN view of the divergence of published opinions and prophecies concerning the Marconi system of space telegraphy, which have tended somewhat to confuse the average reader, the article on this subject that appears on another page should prove of particular interest. From the exposition of the system here given it would seem that its limited application to marine signaling is a practical possibility even now, it being only necessary to equip sea-going craft with the simple apparatus described in order to enable them to communicate with each other over considerable distances. As pointed out in the article, the signals can be made selective only at the expense of radius of action, and when selective apparatus is employed its extreme delicacy of adjustment constitutes an additional drawback. These facts, however, in no wise detract from the practical value of the system as applicable to the merchant marine. There is no special need for secrecy in signals, and if there were, it would be just as effectually obtained by means of private codes as by means of selective apparatus. Such apparatus, as a matter of fact, could not always give perfect immunity from intrusion; the reflector at the transmitter would not prevent the hostile ship from moving into range, and the reflector at the receiver could not monopolize all of the magnetic waves—nor could the intruder be prevented from adjusting his receiver into syntony with the selective transmitter, much as a telegraph operator adjusts his relay for different sending stations on a "heavy" land line in bad weather. So there really appears to be small incentive to the development of selective apparatus, its value being limited to use by naval fleets or intermediate coast stations in order to permit the simultaneous transmission of two or more sets of signals, within a given sphere of influence, without mutual interference. So far as the vertical wire system is concerned, there seems to be no particular reason why it should not be made the subject of practical experiment on sea-going vessels and in coast-line Government stations. The equipment is inexpensive, and the results reported from the installation on the south coast of England are amply encouraging. Any telegraph operator can learn to manipulate the instruments within less time than is required to describe them, and a speed of twenty words a minute is said to be practicable with existing apparatus. Although we are not given to theoretical speculation, more or less irrelevant to work-a-day application, it is of interest to note that the explanation given in our article of the basic principle of Marconi's system has been confirmed by addresses and papers by eminent European authorities, which have been published since the preparation of the article.

CORRESPONDENCE DEPARTMENT.

[*Communications on matters of interest to marine engineers, for insertion in the correspondence department, are solicited. These, wherever possible, should be supplemented by rough sketches or drawings, which will be reproduced, if necessary to illustrate the subject, without cost to the writer.*

Full names and addresses should be given, but publications of these will be withheld where requested.

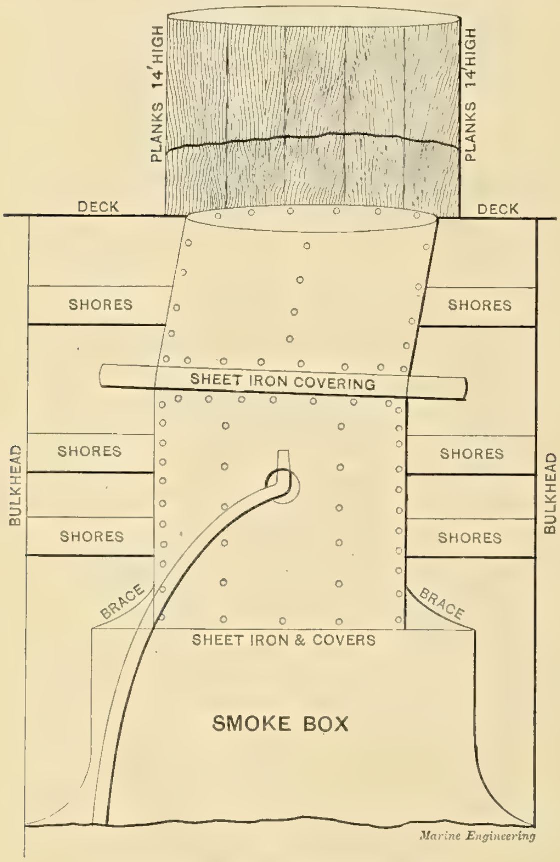
We do not assume responsibility for the opinions expressed by correspondents.]

Engineers Saved the Ship.

Editor of Marine Engineering:

It may interest your subscribers to read a true account of a recent trip of the American steamship *Catania*, 2,600 tons, from Glasgow to New York. On that trip the crew experienced the sensations of persons who realize that they are to be lost at sea. Had it not been for the heroic work performed by the engineers the vessel would surely have foundered and no one lived to relate the story of the struggle to save the ship, a struggle probably as severe as any in the history of steam navigation.

December 18, 1898, the *Catania* left Glasgow in ballast for New York, and all went well until December 21, when the vessel met with a series of hurricanes



JURY FUNNEL AND UPTAKE REPAIRS.

from the northwest which continued and increased in fury from day to day. On December 25 she was boarded by seas which carried away the galley skylight, smashed the sanitary tanks and two life boats. Next day a sea broke over the vessel and carried away her funnel, which broke off at the base on top of the breeching, leaving a 20 ft. section floating around in the fiddlies. The remaining 45 ft. was broken off flush with the deck and carried overboard along with the skylights, life boats, part of the bridge and the port rail. The fires were extinguished, and the vessel lay helpless in the trough of the sea. The engineers worked all night inserting a 2 1-2 in. steam jet in the breeching and shoring up the section in the fiddlies. We tore off the galvanized iron covering from the boilers and patched the holes and seams where the funnel had parted. Then we nursed the fires with oil, generated 20 pounds of steam, got the bilge pumps going, and the engines turning over, about 25 revolutions, and hove the ship to. At daybreak another sea boarded us, putting out the fires again, and starting the starboard boiler from the saddles. The water column pipes (flange ends on boiler) broke and drove every one out of the fire and engine rooms. We were working like fiends getting things in shape, when the Atlantic Transport liner *Mesaba* was sighted in latitude 48 deg. North, longitude 38 deg. West. All the engineers were below and did not know what was transpiring on deck until the next day. Our Captain signaled distress, and asked to be taken in tow by the *Mesaba.* They tried to launch a boat, but it was too rough, and they had to give up the attempt, but they signaled that they would stand by. This they did for 26 hours. Meanwhile the engineers had shored up the loose boiler and had stretched and reflanged the pipe. Then we generated steam and commenced to turn the engines over. At 7.30 p. m. our Captain headed the ship S. by S. E. for the Azores, 790 knots distant, without firing any signal, thus deserting the *Mesaba*, which had stood by us for hours, without a word of explanation. I had the satisfaction later of seeing the Captain regret his act and hear him say, "It remains for the engineers to save the ship."

We had really only got out of one difficulty to meet another still greater. On December 30 the quadrant of the rudder post parted and the vessel fell into the trough of the sea again. The engines raced so hard that Nos. 3, 4 and 5 couplings were loosened (chewing them down three-quarters of an inch. The babbitt metal in the H.P. crank brasses was punched out, and the connecting rod split through the center from the stub end. We were then 790 knots from the nearest port, without a funnel, with the after hold half-full of water, intermixed with mud ballast, with fires extinguished, the quadrant on the rudder overboard, the crew paralyzed with fear, and a Southwest hurricane blowing—that was our New Year's greeting of '99.

After 36 hours' incessant work, during which no one even thought of eating, as it was not to be had, we got steam on again, and finally brought the ship into Ponta Delgada, Azores, with a jury funnel, a patched-up quadrant and other makeshift repairs. We sailed again from the Azores, and arrived at New York harbor, February 7 last. A few days later one of the New York daily papers came out with a long article telling how the Captain saved the ship. I wrote telling them the facts, but my letter never appeared.

THEO. KALISHER,
Second Assist. Eng. S. S. *Catania.*

Discussion of Boiler Manholes.

Editor of Marine Engineering:

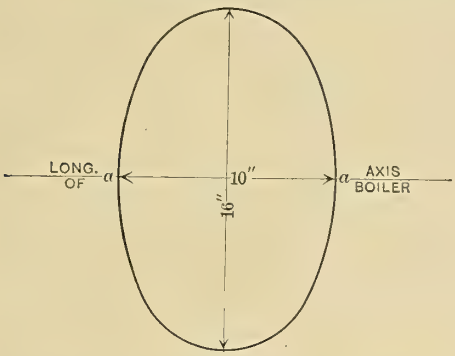
In the April number "Subscriber" asks for a rule to figure the strength of reinforcing rings for manholes. The answer given hardly covers the case. U. S. Inspection Rule says that as much metal must be put around the hole as was taken away. "The Locomotive" (Published by Hartford Steam Boiler Ins. Co.) December, 1896, and April, 1897, has the most complete analysis of the subject to be found anywhere.

The method of treatment, I think originated with Chief Engineer Shock (see his work on Steam Boilers) and is as follows:

When a hole is cut in the shell of a boiler, the strain which the part removed bore must now be carried by the metal at the two edges of the hole in the axis through the middle of the hole and parallel to the longitudinal axis of the boiler.

In the sketch herewith a hole 10 in. by 16 in. is cut in the shell of the boiler. Now it is evident that the

10 in. cut away must be carried by each side, an equal amount. If the shell is 1 in. thick, a piece of metal 1 in. by 5 in. must be placed at points marked *a a* in order to make this part as strong as before the hole was cut. The strap and edges of hole are put into



tension, the same as any other point at the circumference and this equals: radius of boiler × pressure × distance between edges. One-half of this product equals strain at one edge.

CHARLES J. ENGER.

[The answer in the April issue referred to had especial reference to the reinforce rings for manholes in the flat heads of boilers. Practice varies very considerably in the methods of reinforcing such openings, and also of closing them. For manholes in flat heads the chief object of the reinforce ring is to give local strength and stiffness at the edges of the hole, so as to prevent the metal from crushing or buckling under the stress due to the cover or the dogs.

The stress around a manhole and the proper cross section of a reinforce ring are matters which cannot be satisfactorily examined by simple mathematical process. Whatever the stress in the metal at the edge of the hole may be, however, it is certain that it is not one-half the product of "radius of boiler × pressure × distance between edges," given by our correspondent.

Shock in his book on boilers, to which our correspondent refers, concludes that 65 per cent of the section of metal removed is sufficient for the section of the reinforce ring. This matter, like so many others in engineering, must ultimately be settled by safe practice.

In manholes in the front of boilers, the reinforce ring, as we originally described, is usually adopted. In modern practice, however, it is often the custom to flange the plate at the hole, and in such case no reinforce ring is used.

A dimensioned drawing of such an arrangement is given here, Fig. 1. Again, where a manhole or handhole comes close to the through braces, say, for example, below the furnaces, in a Scotch boiler, the reinforce plate is cut in a shape approximating a triangle. At each angle or corner the plate is of sufficient width to let the threaded end of the brace come through, and the outside nut is then jammed down on the reinforce ring, which there takes the place of a washer. This we show in the acompanying drawing, Fig. 2.

Now with regard to the manhole on top, in the shell of a boiler: In earlier days, when steam pressures were low, it was frequently the custom to place a metal box over the manhole riveted on from the outside. The top of this box was faced and covered by a plate held in position with stud bolts or through bolts, after the fashion of a cylinder cover. When steam was up, the tendency of the pressure was to lift the whole contraption off the boiler. With the increase

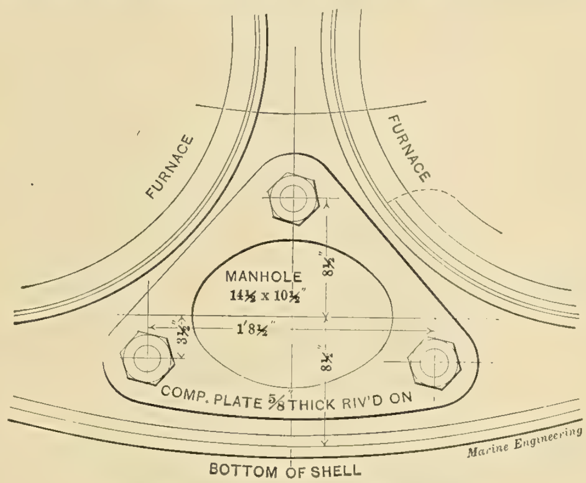


FIG. 2.—MANHOLE BELOW FURNACES.

of pressures some more substantial form of compensation and door was demanded. Doors closing from the inside and held in place with dogs were adopted. In these the tendency of the pressure is to keep the door tight on its seat.

There is no fitting on a boiler which demands greater care in construction than the manhole, though it is not usually looked upon as a problem requiring more than passing consideration. Appended will be found excerpts from the various government and classification society rules on the subject; some give it but brief mention, and other societies do not recognize it at all. Any one who has gotten out of a stokehold in a hurry when a manhole joint blew out will agree as to the importance of the subject.

We give here sketches of actual practice in high-class boiler work. For moderate pressure a cast steel compensating ring, such as shown in Fig. 3 is satisfactory. The flange should be wide enough to permit a double row of riveting, and the

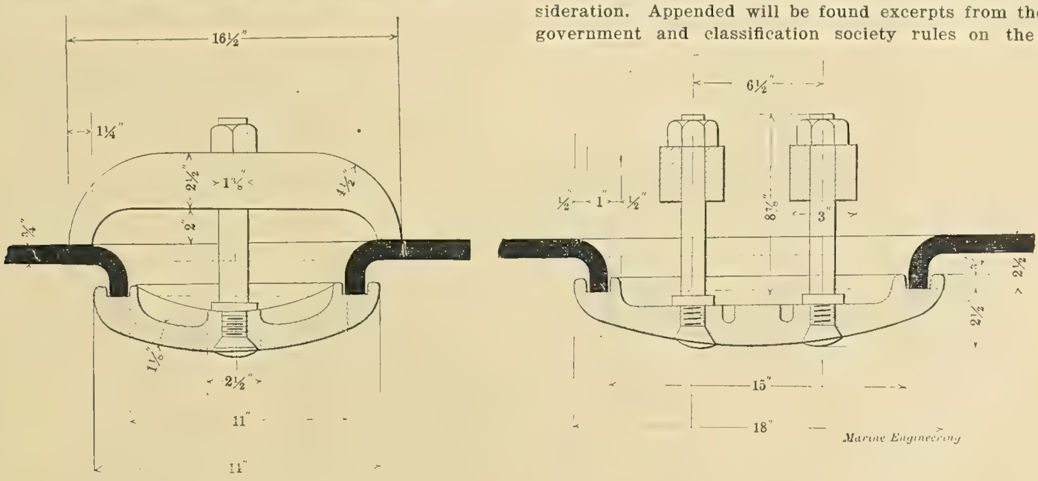


FIG. 1.—MANHOLE IN FLAT HEAD OF CYLINDRICAL BOILER WITH FLANGED OPENINGS.

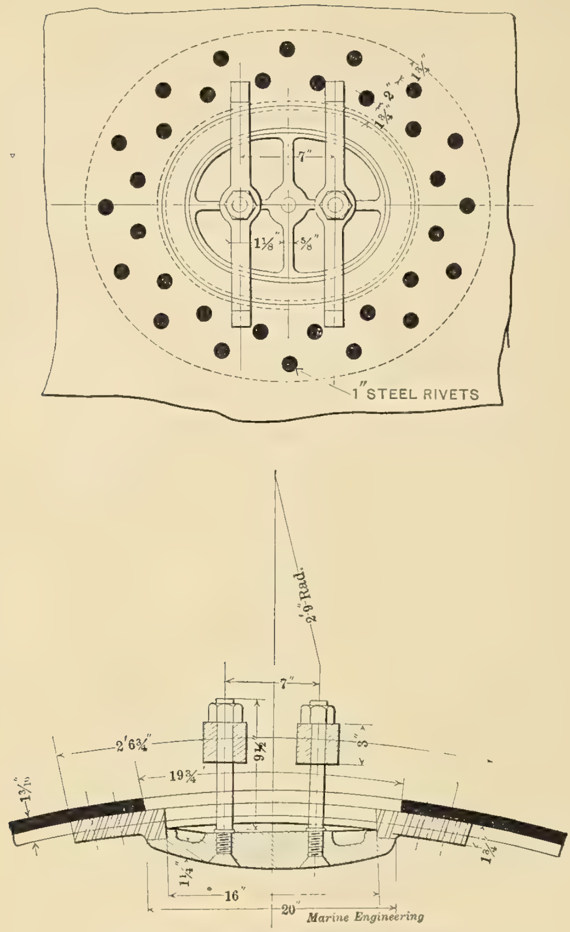


FIG. 3.—12 x 16 MANHOLE IN SHELL.

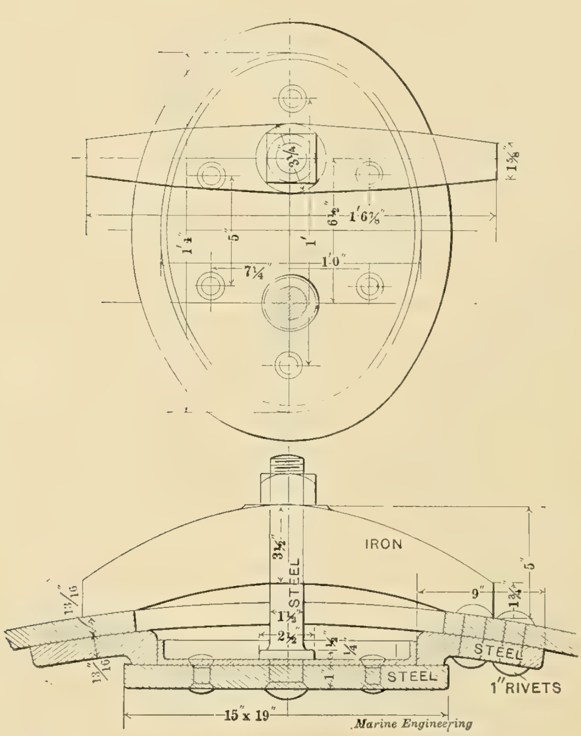


FIG. 4.—12 x 16 MANHOLE IN SHELL.

opening should be less than the opening in the boiler shell. This permits the inner row of rivets to be placed close to the edge of the hole in the shell, so that there will be no spring in the plate when caulked, and a staunch job will result.

The face of the compensating ring should of course be turned true, and the flange of the door faced where the joint is made. Great care should be taken with this joint, the scraper being used if necessary to get true surfaces. The rim running round the cast steel door, Fig. 3, brings the door readily to its proper position and prevents any lateral play. A very safe method of making the joint is illustrated in Fig. 1, already referred to, where the flange in the plate around the hole fits a groove in the door. This is frequently used in the largest work, but it is a more difficult construction than that shown in Fig. 3. In the case of manholes in the shell of this type the curved plate is not flanged, but a heavy angle is riveted on, somewhat after the style of Fig. 4.

The form of door illustrated in Fig. 4 can be recommended for the very highest pressure. It will be noticed that only forged or rolled material is used in its construction. The reinforcing ring is made of the same material as the boiler shell and is the same thickness. It is flanged and then drilled for the rivets and the face is turned true. The door is a slab of high carbon steel of greater thickness than the shell. Riveted to this is a heavy angle, which is a snug fit for the opening in the reinforcing ring. The holding down bolts are steel and the dogs are iron, both of heavy material. The door shown is for a boiler about 12 ft. dia. carrying 125 pounds pressure. For a higher pressure a door of the same design, but proportionately heavier, would be quite suitable. Jointing can be effected by the use of a thin asbestos gasket.

In all cases the short diameter of a manhole in the shell should be placed longitudinally and the long diameter around the boiler.

Following are the rules of various bodies which regulate the construction of manhole fittings:

U. S. Board of Supervising Inspectors.—When holes exceeding 6 in. in diameter are cut in boilers for pipe connections, man and hand hole plates, such holes shall be reinforced, either on the inside or outside of boiler, with reinforcing plates, which shall be securely riveted to the boiler, rivets spaced as for stay bolts, as determined by Section 6, Rule 2, such reinforcing materials to be of wrought iron or steel rings, of sufficient width and thickness of material to equal the amount of material cut from such boilers in flat surfaces; and where such opening is made in the circumferential plates of such boilers, the reinforcing ring shall have a sectional area of at least one-half the area of material there would be in a line drawn across such opening parallel with the longitudinal seams of such portion of the boiler. On boilers carrying 75 pounds or less steam pressure, a cast-iron stop valve, properly flanged, may be used as a reinforce to such opening. When holes are cut in any flat surface of such boilers, and such holes are flanged inwardly to a depth of not less than 1 1-2 in., measuring from the outer surface, the reinforcement rings may be dispensed with.

Bumped heads may have a manhole opening flanged inwardly when such flange has a sufficient depth and thickness to furnish as many cubic inches of material as were removed from the head to form such opening.

Board of Trade, London.—Compensating rings of at least the same effective sectional area as the plate cut out should be fitted round all manholes and openings, and in no case should the rings be less in thickness than the plates to which they are attached. The openings in the shells of cylindrical boilers should have their shorter axes placed longitudinally. It is very desirable that the compensating rings round openings in flat surfaces should be made of L or T iron. Cast-iron doors should not be passed.

Bureau Veritas.—All manholes to be fitted with compensating rings.

Lloyds rule is the same as that of the Bureau Veritas.

Resetting a Slipped Eccentric.

Editor of Marine Engineering:

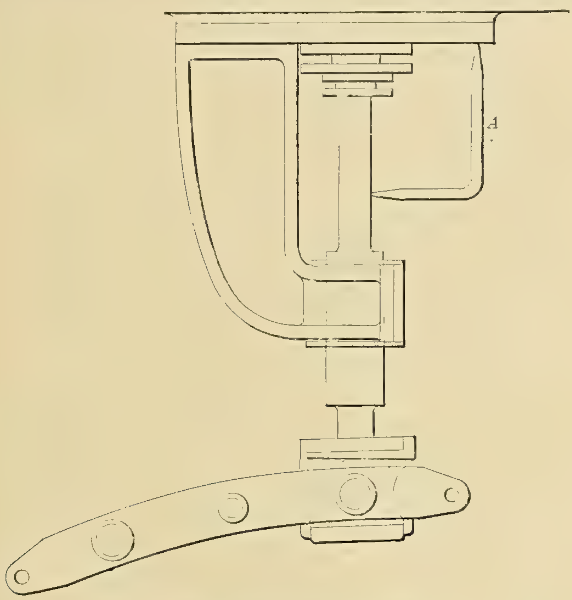
In your April issue, your answer to a question about setting a slipped eccentric is all right as far as it goes, but it does not get the eccentric exactly right, as the valve may leak, which would make it very uncertain. The way to do it and have it right is, to put the engine on the center and place the slipped eccentric somewhere near its proper position, then put the link in full gear with the eccentric that has not slipped, and make a fine mark on the valve stem, say one inch from the stuffing box gland. Then throw the link in full gear with the slipped eccentric and move it (the slipped eccentric) until the mark as before is one inch from the gland, then make it fast.

It must be right with the engine on the center; it does not make any difference which way the engine is going to turn, the valve must have the same lead.

G. V.

[Our correspondent is in error in assuming that an engine must have the same lead whether turning ahead or astern. This would be so had both eccentrics the same setting, but frequently this is not the condition. The correct way to set a Stephenson valve gear of a marine engine is to have a smaller angle of advance in the "go astern" eccentric than in the "go ahead," so that the engine will have a much longer cut off when going astern, and so develop more power to offset the loss of efficiency of the rounded backs of the propeller blades, and this will also diminish the excessive increase in lead when the engine is linked up.

As a matter of fact, however, no first-class engine builder would turn out a large job in which the eccentrics were not



GAUGE FOR SETTING VALVE.

keyed to the shaft. In Corliss engines the eccentrics are usually held in place with set screws, but in this type of engine the eccentric has little weight to carry and frequently two eccentrics are provided, one for the steam and one for the exhaust. In the case of a marine engine, however, where the weight of gear and valves lifted by the eccentrics often runs up into the thousands of pounds, a good stout key is a necessity. Frequently, indeed, the ahead and astern eccentrics of the gear on each cylinder are secured together by a yoke and bolts, so that the key of the astern eccentric will take a share of the load when going ahead.

The only possible occasion, therefore, on which a resetting of the eccentric would call for an investigation of the valve position would be where an offset key was used, and to meet any such emergency would be a simple matter for a competent engineer who was attached permanently to one vessel and who thus had had opportunity to make a good record of his valves.

Should such a key shear while the engine was running, in case the shaft was not marked so that the sheave could be easily brough back to its proper position, the engineer would reset it with the aid of a gauge such as shown at *A* in the accompanying diagram of a valve spindle and link. The chief use of such a gauge is to determine the wear of the valve gear, and it is made thus: When the engine has been run for a time, after leaving the builders' hands, and when all adjustments have been made to get it to run quietly and efficiently, a center punch mark is made on the bottom of the valve chest and another on the valve stem or valve stem crosshead. The crank is then put on the top and bottom centers and in each position gauges, as shown at *A*, are made touching the center points. The gauge is a piece of round iron, bent and pointed at each end. If at any time the valve gear wears so that the valve gets low, all that is needed to get the valve back into its proper position is to turn the engine over and try the gauges. The difference between the end of the gauge and the center point on the valve stem will show the thickness of liner required to be put under the foot of the eccentric rod.

Referring, however, to the original query of "Mass." in our April issue, in case such a gauge was not at hand and a new key had to be fitted, it would be much more sensible to remove the cover, as this is not a very difficult matter, and the cover could be taken off and replaced long before the key for the eccentric was properly fitted.—Ed.]

Just as we are going to press news is received that the American liner *Paris* is ashore on the Manacles off the Cornish coast on which the Atlantic Transport liner *Mohegan* was wrecked. The mishap occurred about 1 o'clock on the morning of May 21, when the passengers were all in their berths. The vessel lies about 150 yards off shore and is hard and fast on the rocks forward, while her stern is afloat. If the weather keeps good it is probable the vessel will be saved. After the mishap the passengers were conveyed ashore without any accident.

The Spanish cruiser *Reina Mercedes*, which was recently raised in Santiago harbor, where she had lain on the bottom for nearly a year, was towed to Hampton Roads May 22. The vessel will be surveyed, and it is probable that a Congressional appropriation will be made to put her in fighting trim again. The *Reina Mercedes* is a steel cruiser, built at Cartagena, Spain, in 1887. Her dimensions are: Length, 280 ft.; beam, 43 ft.; draught, 16 ft. Her displacement is about 3,000 tons. She is fitted with engines of 4,800 maximum horse power, and has a sea speed at full power of 17 knots. Her armament consists of six 6.2 in. breechloaders and a number of smaller weapons, and she has five torpedo tubes.

It is not generally known, but there was a clause in the Deficiency bill which grants certain officers and enlisted men of the Volunteer Navy who served in foreign waters during the war with Spain two months' extra pay, and officers and men who served in the Volunteer Navy in home waters one month's extra pay. These claims are being rapidly adjudicated, and any claimant who has not yet received his pay should address the Hon, Auditor for the Navy Department, Treasury Department, Washington, D. C. A statement of the applicant's naval service should be made, and his final orders detaching him from whatever vessel he was serving on, together with his honorable discharge, should be enclosed with the claim.

The North German Lloyd passenger and cargo steamer *Barbarossa* left her dock in Hoboken May 18, bound for Bremen. Before she passed out at Sandy Hook fire was discovered in her forehold and she was returned to her dock. In coming up the North river she was forced off her course in avoiding a collision with a ferry boat and she rammed the French liner *La Bretagne*, which was lying at her pier. The French liner was struck on the starboard quarter and cut down to about 2 ft. below the water line. Her moorings broke and she was forced ahead, striking and sinking two ice barges which lay between her and the bulkhead. The *La Bretagne* was moved next day to the Erie Basin dry docks for repairs and her place on the line was taken by another of the French company's ships.

EDUCATIONAL DEPARTMENT.

HELPS FOR CANDIDATES FOR MARINE ENGINEERS' LICENSES—MATERIALS OF ENGINEERING CONSTRUCTION—IV.

BY DR. WILLIAM FREDERICK DURAND.

(*Concluding Chapter*).

§ 6. LEAD.

Lead is a very soft, dense metal, grayish in color after exposure to the air, but of a bright silvery luster when freshly cut. Commercial lead often contains small amounts of iron, copper, silver and antimony, making it harder than the pure metal. It is very malleable and plastic. In engineering, lead is chiefly of value as an ingredient of bearing metals and other special alloys. Lead piping is also used to some extent for water suction and delivery pipes where the pressure is only moderate, and where the readiness with which it may be bent and fitted adapt it for use in contracted places.

§ 7. TIN.

Tin is a soft, white, lustrous metal with great malleability. Commercial tin usually contains small portions of many other substances, such as lead, iron, copper, arsenic, antimony and bismuth. It is largely used as an alloy in the various bronzes and other special metals. Tin resists corrosion well and in consequence is often used as a coating for condenser tubes. It is also used for coating iron plates, the product being the so-called "tin plate" of commerce. It melts at about 450 deg., which corresponds to a steam pressure of about 400 lbs. per square inch. Due to this low melting point tin is often used as the composition for *safety plugs* in boilers.

§ 8. ZINC.

Zinc, or "spelter," as it is often called commercially, is a brittle and moderately hard white metal with a very crystaline fracture. The impurities most commonly found in zinc are iron, lead and arsenic. It is used chiefly as an alloy in the various brasses, bronzes, etc., and as a coating for iron and steel plates, rods, etc. The process of applying zinc for such a coating is called "galvanizing," and the product "galvanized" iron or steel. Electricity, however, is not used in the process, the articles, after being well cleaned, being simply dipped in a tank of melted zinc and then withdrawn. Slabs of zinc are also used in marine boilers to prevent corrosion.

§ 9. ALLOYS.

A mixture of two or more metals is called an *alloy.* The properties of an alloy are often surprisingly different from those of its ingredients. The melting point is sometimes lower than that of any of the ingredients, while the strength, elastic limit and hardness are often higher than for any of them.

Mixtures of *copper* and *zinc* are called *brass.* Mixtures of *copper* and *tin*, or *copper*, *tin* and *zinc*, with sometimes the substances in small proportion, form *gun metals, compositions* and *bronzes.* These terms are, however, rather loosely employed. Various mixtures of two or more of the metals—*copper, tin, zinc, lead, antimony*—form the various bearing metals.

Brass and composition are used for piping and pipe-fittings; globe, gate, check and safety valves; condenser tubes and shells: sleeves for tail shafts, and for a great number of small fittings and attachments for which the metal may be suited. The bronzes are employed for many of the uses of brass where more hardness, strength or rigidity are required. They are used with especial success as a material for propeller blades.

The white metals, supported or backed by some other metal, such as brass, cast iron or cast steel, to give the necessary strength, are now very largely used for bearing surfaces.

PROPORTIONS OF INGREDIENTS FOR VARIOUS ALLOYS.

In the following proportions the numbers after the ingredients denote the number of parts in 100 of the mixture. They represent either the usual proportions, or the results of special analyses of samples, and have been collected from various sources. The alloys are arranged in the alphabetical order of their names to facilitate ready reference:

Admiralty Bronze.—Copper 87, tin 8, zinc 5 .

Aluminum Brass.—Copper 63, zinc 34, aluminum 3.

Aluminum Bronze.—Copper 89 to 98, aluminum 11 to 2.

Anti-Friction, A.—Zinc 1, iron .65, lead 78.75, antimony 19.6.

Anti-Friction, B.—Copper 1.6, tin 98.13, iron trace.

Anti-Friction, C.—Copper 3.8, tin 78.4, lead 6, antimony 11.8.

Babbitt (Light).—Copper 1.8, tin 89.3, antimony 8.9.

Babbitt (Heavy).—Copper 3.7, tin 88.9, antimony 7.4.

Brass, Common Yellow.—Copper 65.3, zinc 32.7, lead 2.

Brazing Metal.—Copper 84, zinc 16.

Brazing Solder.—Copper 50, zinc 50.

Bush Metal.—Copper 80, tin 5, zinc 10, lead 5.

Delta Metal.—Copper 50 to 60, tin 1 to 2, zinc 34 to 44, iron 2 to 4.

Deoxidized Bronze.—Copper 82, tin 12.46, zinc 3.23, iron .10, lead 2.14, phosphorus trace, silver .07.

Gun Metal.—Copper 89, tin 8.25, zinc 2.75.

Magnolia.—Tin ?, zinc trace, iron trace, lead 83.55, antimony 16.45.

Manganese Bronze.—Copper 88.64, tin 8.7, zinc 1.57, iron .72, lead .30

Muntz Metal.—Copper 60, zinc 40.

Navy Brass.—Copper 62, tin 1, zinc 37.

Navy Composition.—Copper 88, tin 10, zinc 2.

Navy Journal Boxes.—Copper 82.8, tin 13.8, zinc 3.4.

Parsons White Metal.—Copper 1.68, tin 72.9, zinc 22.9, lead 1.68, antimony .84.

Phosphor Bronze.—Copper 90 to 92, phosphide of tin 10 to 8.

Steam Metal.—Copper 85, tin 6.5, zinc 4.25, lead 4.25.

Tobin Bronze.—Copper 59 to 61, tin 1 to 2, zinc 37 to 38, iron .1 to .2, antimony .30 to .35.

White Metal.—Lead 88, antimony 12.

§ 10. THE TESTING OF METALS.

[1] DIFFERENT KINDS OF TESTS.

Metals may be tested for strength in various ways—in *tension*, by pulling apart a test piece of specified pattern and size; in *compression*, by crushing a piece of suitable dimensions; in *cross breaking*, by supporting a bar at two points and breaking or bending it in the testing machine by a load applied at an intermediate point; in *torsion*, by twisting apart a bar in a machine especially designed for the purpose; in *direct shearing*, by breaking a riveted or pin-joint connection in the usual machine; for *impact* or *shock*, by letting a weight drop through a certain height and by its blow develop suddenly the stress in the material.

[2] EXPLANATION OF TERMS USED.

Ultimate Strength.—The ultimate strength of a test piece is the load required to produce fracture, reduced to a square inch of original section; or in other words, the ultimate or highest load divided by the original area. Thus if the area of the cross-section of a test piece is .42 sq. in. and the load producing fracture is 28,400 lbs., the ultimate strength equals 28,400÷.42=67,620 lbs. per square inch.

Elastic Limit.—The elastic limit is the smallest load, reduced to one square inch of area, which will produce a permanent set or distortion of the material. Thus in a tension test if the cross-section is .68 sq. in. and a permanent elongation or set is just produced by a load of 27,600 lbs., the elastic limit is at 27,600÷.68=40,600.

Elongation.—A certain length being marked off on the test piece as described in [3], [4], the percentage of elongation is found by dividing the actual extension of the length just before rupture by the original length, and reducing to per cent. Thus if a length of 8 in. is marked off on the test piece and

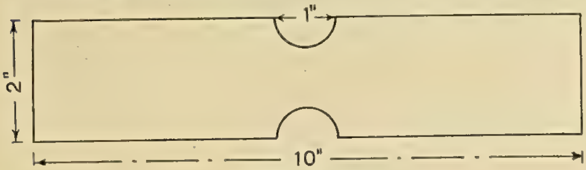


FIG. 1.

if the length between the same marks at fracture is 10.2 in., the actual elongation is 2.2 in. and the per-percentage elongation is 220÷8=27.5%. When a test piece is first put under load the elongation is distributed nearly uniformly over its length. This con-

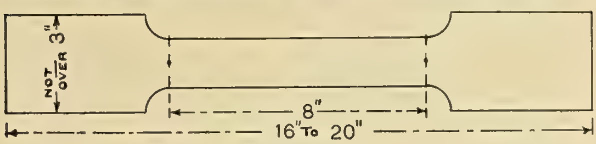


FIG. 2.

tinues until the piece begins to neck down near the point of final fracture. Nearly all of the remaining elongation is restricted to the immediate vicinity of this point. Hence the percentage elongation with a short length of test piece may be much greater than with a long piece. A few years ago, for example, when test pieces 2 in. long were not uncommon, the actual elongation might be nearly 1 in., and thus percentage elongations approaching 50 per cent were

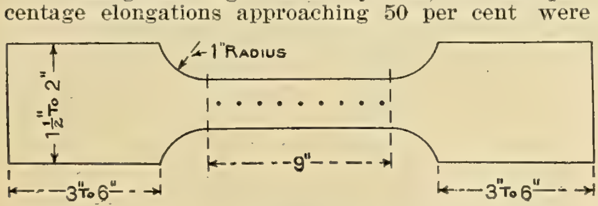


FIG. 3.

found. In modern practice the length of a test piece is usually 8 in. and values of the percentage elongation over 30 per cent even with vastly superior material, are rarely met with. In reporting elongation the length used should always be stated.

Reduction of Area.—The percentage reduction of area is found by subtracting the final area of the section at the point of fracture from the original area at the same point, dividing the difference by the latter, and reducing to per cent. Thus if the original area is .68 sq. in. and the final area is .36 sq. in., the actual reduction is .68—.36=.32 sq. in., and the per centage reduction is 32÷68=47.5 per cent.

For the measurement of the areas of cross-sections,

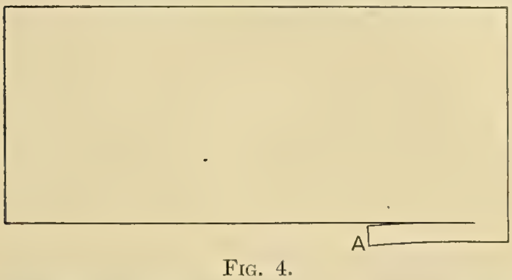


FIG. 4.

especially when of irregular form, reference may be made to Chap. I., §9 [15].

[3] TEST PIECES FOR IRON.

In modern practice the form of test pieces for iron is usually the same as for steel, and as described in [4]. The form of test piece for wrought iron plate prescribed by the U. S. Board of Supervising Inspectors of Steam Vessels is, however, somewhat different, and is illustrated in Fig. 1. If the plate is 5-16 in. thick or less, the width at the reduced section must be one inch. If the plate is over 5-16 in. in thickness, the width of the piece must be reduced so that the cross-sectional area at the reduced section shall be about .4 sq. in., but it must not be greater than .45 sq. in. nor less than .35 sq. in.

[4] TEST PIECES FOR STEEL AND OTHER MATERIALS.

Fig. 2 shows the form of test piece for tension pre-

FIG. 5.

scribed by the Navy Department for tests of steel plate for naval uses.

Fig. 3 shows the form prescribed by the Association of American Steel Manufacturers, and adopted by the U. S. Board of Supervising Inspectors of Steam Vessels. The test piece for plates is cut from a "coupon," as it is called, left on one corner of the plate as shown at *A*, Fig. 4. The U. S. law requires further that:

"Every iron or steel plate intended for the construc-

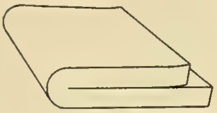


FIG. 6.

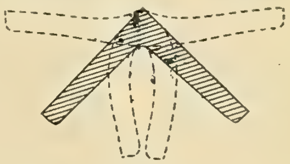


FIG. 8.

tion of boilers to be used on steam vessels shall be stamped by the manufacturer in the following manner: At the diagonal corners, at a distance of about 4 in. from the edges and at or near the center of the plate, with the name of the manufacturer, the place where manufactured, and the number of pounds tensile strain it will bear to the sectional square inch."

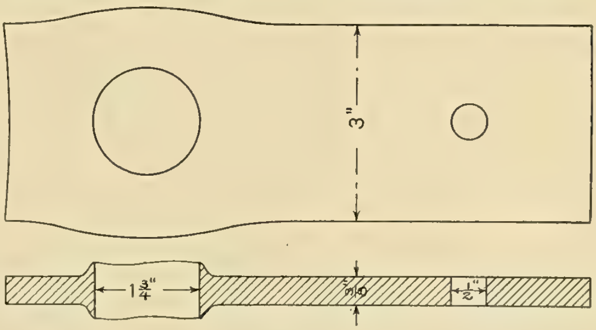


FIG. 7.

Fig. 5 shows the usual round form of test piece for all material except plates.

[5] BENDING, QUENCHING AND HAMMER TESTS.

The nature of these tests has already been described in §5, [5], (11).

Fig. 6 illustrates a cold bending test on a piece of steel plate. A *drift* test is also sometimes required. This is illustrated in Fig. 7, and consists in driving taper drifts of continually increasing size into a punched or drilled hole until the diameter is increased to at least twice its original size. The metal must stand this test without sign of fracture about the edges of the hole.

Bending tests for angle and Tee irons, as described in §5 [5] (11), are also illustrated in Fig. 8.

ELECTRICITY ON BOARD SHIP—PRINCIPLES AND PRACTICE—XVIII.

BY WM. BAXTER, JR.

SAFETY FUSES AND LIGHTNING ARRESTERS.

Field rheostats, which are very commonly called "field regulators," are simply resistances so arranged that they can be cut in or out of the circuit of the shunt field coils of a generator. Generators are always designed to develop the required voltage at a fixed velocity, but as can be readily understood it is not possible to hit the mark exactly, hence if the machine is intended to run at, say, 600 revolutions per minute to develop a voltage of 110, it may, when tried, be found to require a speed of 590 or 610 revolutions. If it requires the latter velocity, all that can be done is to speed it up, but if it will give the desired voltage at the lower speed, then the excess of e. m. f. at 600 can be prevented by inserting in the shunt field circuit a sufficient amount of resistance, and it is for this purpose that the field rheostat is employed. Again, it may not be convenient to run the generator up to the exact speed for which it is designed, or it may be necessary to run it somewhat faster; therefore, if no means of regulating the voltage were provided, the attainment of satisfactory results would not be possible. In order to be on the safe side, generators are always made so that they will develop, at the rated velocity, a voltage somewhat higher than that at which they are expected to run, and then by means of the field regulator the e. m. f. is adjusted to the proper point.

The principle upon which field regulators act is very simple. To illustrate it, suppose we have a generator that develops an e. m. f. of 115 volts when running at the speed that we intend to adopt; then if we introduce resistance in the circuit of the shunt field coils, the current passing through these will be cut down and, therefore, the magnetism will be reduced and thus the voltage lowered. Let us suppose that the shunt coils have a resistance of 50 ohms, then if we desire to reduce the e. m. f. from 115 to 110 we will have to increase the resistance of the circuit enough to cut the current down about five per cent. As a matter of fact we will have to reduce the current more than five per cent, owing to the fact that the magnetism will not reduce in the same proportion as the current; but for the sake of an illustration we can suppose that the current and the magnetism will reduce at the same rate. Now as we have to reduce the current about five per cent, we must increase the resistance in a corresponding amount; therefore as the resistance of the shunt coils is 50 ohms, we will have to add about two and a half ohms, thus increasing the total resistance to 52.5 ohms.

The foregoing calculation is based, as we have stated, upon the assumption that the magnetism and the field magnetizing current change in the same proportion, but in reality the magnetism reduces much slower than the current strength, and the difference between the rate of reduction of the two depends, in part, upon the character of the iron of which the field is made, but principally upon the degree to which the field is magnetized. If the magnetization is very strong, a reduction in the strength of the field current of 10 per cent may not reduce the magnetism more than two or three per cent. On this account, the amount of resistance introduced in the field rheostat has to be much larger than would be supposed at a first glance. As a rule the field rheostats have a resistance of from 20 to 50 per cent of the shunt coil resistance.

Field rheostats can be made of anything that offers resistance to the passage of an electric current, and that at the same time is of such a nature that it can be put into a mechanical and durable form. The most commonly employed substance is wire, generally iron or German silver. In most cases the wire is wound in the form of coiled spring and is then stretched out sufficiently to separate its turns from one another.

A simple form of field regulator is shown in Fig. 101. The apparatus consists of a box *F*, which can be made of any suitable material, wood, sheet metal, cast iron, etc. In former days wood was very com-

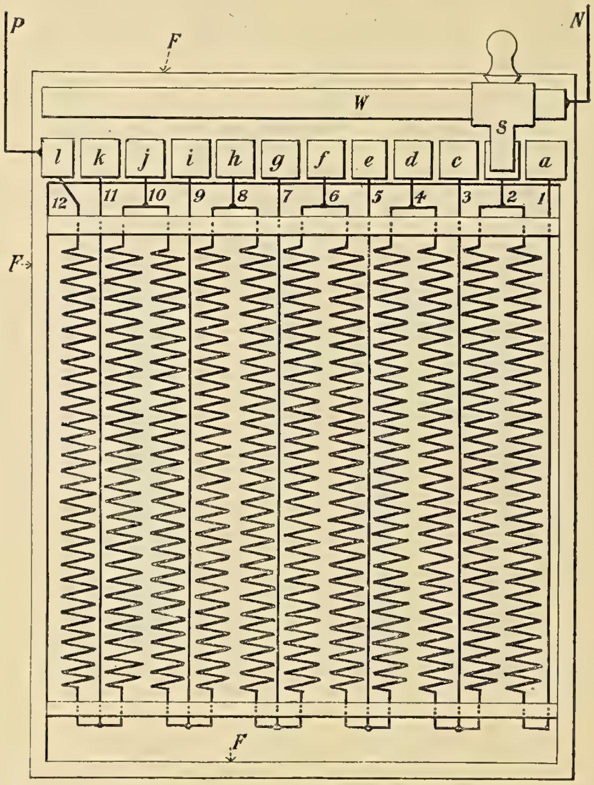


FIG. 101.

monly used, but at the present time in the most generally used construction the sides of the box are made of cast iron and the back of sheet iron, the object of using metal being to render the box fire proof. The way in which the coils are held in place is clearly shown in the figure, and it may only be necessary to add that the double bottom and top are provided so as to cover the connections of the ends of the several coils, and thus not only make the structure more mechanical in appearance, but also more substantial, as the connections are guarded against injury, and are not liable to be touched by the attendant.

In connecting the box in the shunt field circuit, the latter is opened at any convenient point, and the ends are connected with the wires *N* and *P*. As will be seen *N* is connected with a bar *W* and *P* with block *l*. The connection between *W* and *p* is effected by means of the switch *S*. When this switch is placed upon block *a* the current will have to pass through all the wire coils before it can reach block *l*, hence, all the resistance of the apparatus will be in the circuit. If *S* is moved ahead so as to rest upon block *b*, the current will enter the resistance coils through wire *2* and thus cut out the first coil. As the switch *S* is advanced, from block to block, coil after coil will be cut out and when block *l* is reached all the resistance will be out of the field circuit. From this explanation it can be seen that the amount of resistance inserted in the field circuit can be adjusted by the position of the switch *S*.

The position where *S* must be left is determined by the voltage of the current, therefore the field regulator should be placed in such a position that its switch handle can be moved while the attendant is looking at the dial of the voltmeter. If the voltage is too high, *S* is moved back toward *a*, and if the voltage is too low, *S* is moved forward, towards *l*. When the proper voltage is obtained, the switch is in the proper postion and is allowed to remain there.

The design of field regulator shown in Fig. 101 is

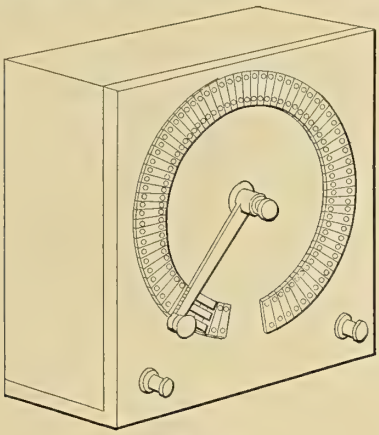


Fig. 102.

very seldom used in actual practice, as it is inferior in many ways to the design shown in Figs. 102 and 103, which are illustrations of well known types of field regulators in common use. We have employed the design of Fig. 101 to explain the construction and principle of action of the device, as it shows more clearly the circuit connections than the construction of Figs. 102 and 103. It can be readily seen, however, that the switch *S* will not move as freely as the

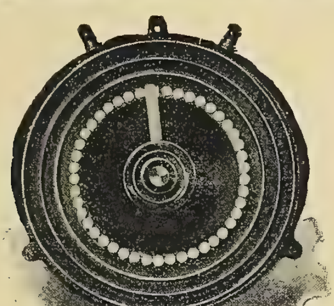


Fig. 103.

rotating arm of Figs. 102 and 103, and furthermore, if we used the same number of contacts *W* would have to be made about twice as long as the width of the entire box in Fig. 103. In Fig. 101 only twelve contacts are shown, for the sake of simplicity, but in actual rheostats, the number is much greater, as shown in Figs 102 and 103. A great number of contacts is required so as to obtain close adjustment of the voltage, upon the same principle that many weights are required to weigh with accuracy. If we had a balance scale and ten one-pound weights, we would not be able to determine the weight of anything closer than a fraction of a pound, for if it weighed more than, say, four pounds, it would be underbalanced with four of the weights and would be overbalanced with five. If, however, we had 160 one-ounce weights, we could determine the weight to within less than one ounce. If we had a field regulating rheostat with ten contacts, we could not set the switch so as to obtain a voltage as near to the desired point as with a greater number of contacts. As an illustration, suppose we desired to obtain a voltage of 110 and that we found that by cutting in five sections of the rheostat we could get 112. We would then cut in another section, and this might cut the voltage down to 108, and we would be powerless to effect a closer adjustment except by varying the speed of the generator. If, however, we had a regulator with forty contacts, we could obtain three different voltages between 112 and 108 and one of these might be very near to the 110 mark, say 110.5 or 109.5. Thus it will be seen that the object of providing a great number of contacts is to provide means whereby the voltage may be adjusted nearer to the required standard.

The field regulators made for small generators may have not more than twenty contacts, while those for very large machines may have as many as eighty or one hundred, the average being between forty and fifty.

Rheostats made of wire coils suspended in the air, as shown in Fig. 101, are rapidly giving away to those of more compact form, such as shown in Figs. 102 and 103. The advantages of these designs are not only that the space occupied by the apparatus is reduced, but also that they are more durable. Fig. 102 is what is known as an "Enameled rheostat." It consists of one or several cast iron plates upon which fine iron wire is attached by means of a coating of enamel. The iron is first coated with a layer of enamel and then the wire is placed upon this and is covered with a second coat. The wire being embedded in the enamel is protected from the action of the air and therefore can be heated to a high degree without danger of becoming oxydized, and on this account much smaller wire can be used than in rheostats of the type shown in Fig. 101.

The rheostat shown in Fig. 103 is made of rods of carbon, which are supported by means of insulating material. This type of rheostat can also be made smaller than Fig. 101, as the carbon rods can withstand a much higher heat than the bare iron wire. In all types of rheostats the part that forms the resistance must be well insulated from the supporting frame. In Fig. 101, if *F* is made of wood, the wires can be run through holes bored therein, the wood itself being sufficient insulation providing it is saturated with varnish, so as to make it water proof; if the frame *F* is of metal, porcelain bushings are inserted in all the holes through which the wires pass. In Fig. 102 the wire is insulated from the frame by means of the enamel, and in Fig. 103 the carbon rods are insulated from the frame by means of fire proof insulating material.

Safety fuses are sometimes used upon switch boards, but as a rule their use is confined to other parts of the circuit. A safety fuse serves the same purpose as a circuit breaker, but its action is not so reliable. The principle of safety fuses can be understood from Fig. 104. If the terminals *a b* of the wires

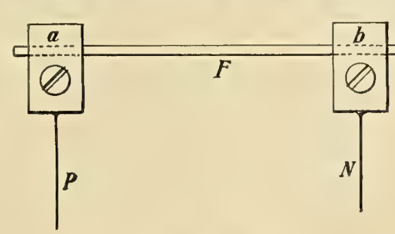


Fig. 104.

P N are connected with each other, by means of a rod *F*, a current will pass from *a* to *b* through the rod, and if the latter is made of smaller size than *P* and *N* it will melt, if the current strength is increased, before the latter will. If *F* is very much smaller than *P* and *N* it will be melted by a current that is not strong enough to heat the latter to any noticeable extent. When *F* is given this proportion it becomes a safety fuse, as it will melt and thus open the circuit before the current becomes strong enough to injure *N* or *P*. The fuse *F* can be made of any kind of wire, the only requirements being that it be so proportioned that it will melt before the current becomes so strong as to overheat other portions of the circuit. As a rule fuses are made of alloys of lead, tin and bismuth that melt at low temperatures and with a much weaker current than the same size copper wire can carry with safety. In warm weather a fuse will melt with a weaker current than in cold weather, hence they are not as reliable as a circuit-breaker. A circuit-breaker will fly open as soon as the current reaches a certain strength, but a fuse will not melt until the current has had time to heat it to the melting point, hence, the former is a better protection against a sudden increase in current strength, the latter only acting when the current continues of increased strength for some time. When fuses are used in switchboard work, they are placed on the back of the board.

Lightning arresters are sometimes used on switchboards, but, as a rule, they are located at other points in the circuit. Lightning arresters provide a path around the apparatus in the circuit that they are intended to protect, so that the discharge may pass to ground without doing damage. The principle of construction can be explained in connection with Fig. 105, which shows one of the simplest forms. *A* is a

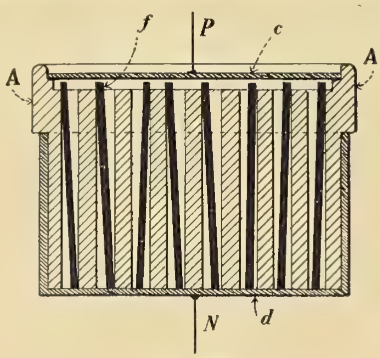


Fig. 105.

porcelain cylinder, made with a number of holes, into which are dropped pieces of fuse wire *f*. The wire *P* is connected to a copper plate *c*, and *N* connects with a copper cup *d*. The fuses are generally of such length that they come within about one-sixteenth of an inch of the plate *c*. When a lightning discharge reaches *c* it will jump to one or more of the fuses *f*, on account of its enormous e. m. f. The generator current, of itself, cannot jump across this space, but if the current is carried over by the lightning, then the generator can keep up the flow and thus become short circuited. But the generator current will not flow many seconds before the fuses will melt and open the short circuit. All lightning arresters are so made that if the generator current follows up the lightning discharge, they will open the circuit to ground formed through them. Fig. 106 shows one of the best known types of lightning arresters, called the magnetic blow-out arrester. In this device the lightning discharge jumps across from the lower corners of the light-colored plates shown at the top of the magnet, these plates being very close together at this point. If the generator current follows the lightning it energizes the magnet, and the magnetic lines of force push the arc formed by the current to the top of the plate, where the distance is so great that the current breaks.

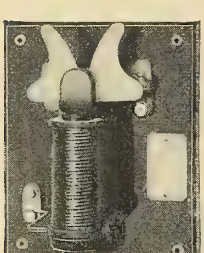


Fig. 106.

At the Morris Heights, N. Y., shipyard the new steam yacht *Kanawha* for John P. Duncan, of New York, was launched May 27. She is 192 ft. long.

ENGINEERS' DIRECTORY—XVII.

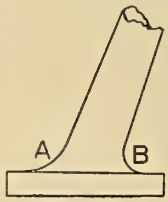


Fig. 73.

Fillet.—Where a piece of metal suddenly changes its shape or size it is always desirable to fill in the corner between the two parts, thus connecting one part with the other by a corner rounded or concave rather than square. This furnishes a relatively easy change from one size or shape to the other and decreases the likelihood of a crack or failure at the angle. The filling in at such a corner is known as a *fillet*, and is illustrated at *A* and *B*, Fig. 73.

Fire Box.—A kind of boiler furnace of nearly rectangular or box-shaped form. The term is more commonly used in referring to the *fire-box* type of boiler. See under *Boiler*, Fig. 7.

Fire Bridge.—See under *Boiler*, Fig. 6.

Fire Clay.—The clay of which fire bricks are made. A good fire clay should have a composition about as follows:

Silica	50 to 60
Alumina	20 to 30
Fluxing constituents	2 to 3
Water	remainder in 100 parts

Fireman.—One of the engineer's force whose duty it is to care for and regulate the fires. His duties consist chiefly in throwing the coal evenly upon the fires and in cleaning them and removing the ashes, all at regular intervals. In British practice the term *stoker* is usually employed.

Fire Room.—The space in front of the boilers from which the fires are worked. Also called *stokehold.*

Fires.—The burning fuel on the grates. For *banked fires* see under *banked.* To *haul* fires means to pull the burning fuel from the furnaces out upon the fire-room floor, leaving the grates bare. To *spread* fires from the *banked* condition means to spread the fuel evenly over the grates, add fresh fuel as may be needed, supply the proper draft, and bring the fires into an active condition.

Fire Tools.—The tools with which a fire is cleaned and kept in order. The usual tools are as follows: *Slice bar*, large and small; *pricker bar*, large and small; *hoe* and *shovel.* The slice bar is straight, with a slightly flattened or triangular pointed end. It is used to run in on the grate and underneath the fire in order to break up the clinker formation, and to free the fire from the grate and give the air a better chance to penetrate the fire. The large pricker bar, which is similar in form to the ordinary poker, is sometimes used for the same purpose. The small pricker is used to clear out the grates from the ash pit without opening the furnace door. The hoe is used for hauling and banking fires and for pulling the ashes from the ash pit, while the shovel is used to handle the coal and ashes.

Fire Tube.—A boiler tube in which the fire or hot gas is on the inside and the water on the outside.

Fire Tube Boiler.—A boiler in which the tubes have the fire or hot gas on the inside and the water on the outside. See *Boiler.*

Flange.—A ring or fringe of metal standing usually at right angles to the main piece to which it is attached or of which it forms a part, and serving for the attachment of other members or parts. Thus a boiler head is flanged for the attachment of the shell and the furnaces. (See *Boiler*, Fig. 6.) The cylinder barrel has a flange to which is attached the cylinder cover. (See *Engine*, Fig. 54.) Two pieces of shaft are connected by a flange coupling, as shown under *Coupling*, Fig. 38.

Flanged Joint.—A joint made by the use of flanges, often with some form of fibrous or sheet packing between.

Float.—The acting part of a paddle wheel. Floats are of two kinds, *feathering* and *radial* or *fixed.* For a description of the former see under *Feathering*. Radial floats are rigidly attached to the arms of the wheel, as shown in Fig. 74. Radial or fixed floats are usually made of wood, feathering floats of either wood or steel plate. The term float is also used in its general sense to denote any part of an apparatus

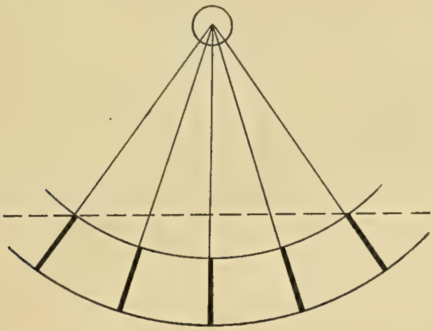


Fig. 74.

which floats partially submerged in a liquid, thus serving to show its level, or to perform some desired operation as it rises and falls with varying level, as in certain forms of steam trap, automatic feed controller, etc.

Flue.—A portion of a boiler cylindrical in form and containing hot gas and surrounded with water, and differing from a tube simply by reason of its size. Flues are usually from 6 in. to 8 or 10 in. dia., while tubes are from 2 to 3 or 3 1-2 in.

Flush Head Bolt or Rivet.—See under *Countersunk.*

Foaming or Priming.—A disturbed condition of the water in the boiler, of such a nature that the water level is more or less uncertain in location and the steam space is partially filled with foam or a mixture of foam and water. In severe cases of foaming steam seems to be given off from almost the entire mass of water in the boiler, causing it to rise bodily as foam and water and fill the whole steam and water space, thence entering the steam pipe and passing on to the engine. In other cases the water seems occasionally to rise in gulps, nearly unmixed with steam, and entering the steam pipe, pass on to the engine. The terms *foamiug* and *priming* are often used as meaning practically the same thing. Where a difference is implied foaming is understood to apply more especially to the uplifting of the mixed steam and water as foam, while priming may refer more particularly to the lifting of water as such and its passage over into the engine. There is, however, no clear line of distinction between the two kinds of disturbances, and there are all grades intermediate between the extremes. Foaming may be due to the presence of certain forms of oil or grease or other impurities in the water, or to a demand for steam too large in proportion to the steam space in the boilers. A sudden change in the character of the feed water may also produce foaming. In former days, when jet condensers were in common use, boilers were liable to foam in passing from sea water to fresh water, especially if the latter was muddy, and again in passing from fresh water back to sea water. In modern practice foaming is usually due either to the presence of oil or to an extreme demand for steam from the boiler. In the former case the oil must be removed by a free use of the surface blow and kept out by a proper filter. In the latter case the engine must be slowed and the demand for steam reduced to an amount which the boilers can supply without the danger of such disturbance. As the result of foaming the engine slows down, power and speed are lost, while due to the possible inability of the relief valves to handle all of the water coming into the cylinders, there may be serious danger of breakdown. There is also danger to the boiler in foaming, because the water level cannot be known with any certainty, and plates or tubes may become overheated, resulting possibly in collapse with serious consequences. The tendency to foam is, therefore, a symptom of serious import, and no steps should be neglected to discover, and, if possible, to remove the cause.

Follower or Follower Plate.—The ring or plate which holds the packing rings of a piston in place.

Follower Bolts.—The bolts which secure the follower to the piston head. For this purpose *stud* bolts are always used. See under *Bolt.*

Foot Valve.—In general a check valve in the suction passage to a pump. It is more particularly used in reference to a valve at the bottom of the air pump cylinder, or between the condenser and the cylinder. See *Air Pump*, Fig. 2. *C.*

Forced-draft.—Draft which is forced or urged, usually by fans or blowers, beyond what would be given by the funnel alone. With the latter alone the draft is usually known as *natural*, or *stack* draft. While there is no sharp line of separation between *natural*, *assisted* and *forced*-draft, the latter is usually considered as meaning a draft pressure of from 1 1-2 or 2 in. of water upward to 5 or 6 in. (See under *Air Gauge*). Occasionally, however, the term is used as implying simply a mechanically assisted draft, giving a pressure of from 3-4 in. of water to 1 or 1 1-2 in.

There are four fairly distinct systems of forced draft: (1) closed fire-room, (2) closed ash-pit, (3) exhaust blowers between the uptakes and funnel, (4) steam jets in base of funnel.

In the close fire-room system the air is forced by means of blowers into the fire-room, which is closed air-tight except for the outlet into the furnaces. The chief advantages of this system lie in the fact that the boilers are left unchanged as for natural draft, and the shift from one system to the other is readily made. The necessary structural arrangements are also sometimes more readily effected than for the other systems, especially in warship practice, and this reason may in some cases largely determine the choice. Its chief disadvantages lie in the difficulty of making the fire rooms air tight, in the necessity of fitting *air-locks* (see under that term) for entering and leaving the fire-rooms, and in the more severe strain placed on the fire-room force than with the other systems.

In the closed ash-pit system the air is forced by means of blowers into conduits leading directly to the ash-pits and furnaces. The *Howden forced draft*, which is representative of this system, involves also as a fundamental feature the heating of the air by means of the waste furnace gases before it enters the ash-pits and furnaces. This method requires the fitting of special ducts from the blowers to the ash-pits, of suitable passages for admitting the air on top of the fire through the inner furnace door lining, and also of a special arrangement of uptake with a nest of vertical air-heating tubes through which the waste gases pass, and around which the air passes on its way to the ash-pits.

Induced draft is represented by the *Ellis and Eaves* system, in which a large exhaust fan is so placed as to draw the gases along the uptakes and discharge them to the funnel, thus producing the draft by means of a defect of pressure in the uptakes, rather than by an increase in the ash-pit or fire-room. The air which in this case is supplied either by natural ventilation or by special blowers is heated before reaching the furnaces by being drawn through or around tubes, around or through which the furnace gases pass on their way to the fan. The chief disadvantage of the induced system lies in the large size and weight of fan necessary to handle the gases, as compared with the much smaller size needed for the air alone in the other systems. The two latter systems with the air heating feature, however, have proved very successful, and have shown that fairly high rates of combustion may be reached (20 to 30 lbs. per sq. ft. of grate surface) without undue loss of economy, and even in some cases with actual gain over the results of much lower rates of combustion under ordinary methods.

The installation of these systems requires great care and an accurate knowledge of the conditions to secure the proper results.

The action of a steam jet in the base of the funnel is to produce a defect of pressure in the uptake, thus giving a form of induced draft. Turning the exhaust of a non-condensing engine into the funnel produces the same result, and may be considered also as giving a form of induced draft. The latter arrangement is sometimes met with in tugs and other small craft, while the steam jet is much used throughout the whole range of tugs, yachts, launches, tenders and all forms of small craft. One of the special advantages of the steam jet is its readiness for use as soon as a small head of steam is formed, and independent of the operation of the main engine.

During the past few years there has been a great extension in the use of forced draft in the mercantile marine, either the *Howden* or *Ellis and Eaves* system being usually fitted, on account of the excellent showing in economy which they have made.

Fork.—A rod made at one end into a Y or U shaped form. See under *Eccentric Rod Fork*, Fig. 52.

Forked Connecting Rod.—A connecting rod formed into the U shape at the upper end. See under *Connecting Rod*, Fig. 35.

Foundation or **Foundation-Plate.**—A term having about the same meaning as *Bed-Plate*, which see The term *foundation* alone is also sometimes used in reference to the specially strengthened structure of the ship under certain parts of the machinery, as, for example, the main engine or the thrust bearing. The term *seating* is, however, more commonly used in referring to this structure.

Front-Connection.—In a return fire-tube boiler, the passage leading the gases from the front ends of the tubes to the base of the funnel. This passage is more generally known as the *uptake*, or, if a distinction is to be made, the latter term refers to the passage as a whole, while the term *front-connection* may be used in particular reference to the lower part of this passage, or that part immediately in front of the boiler. See under *Boiler*, Fig. 6.

Front-Connection Doors.—Doors swinging upward and occupying practically the entire front of the front-connection. Their purpose is to allow examination of the front-tube sheet and tubes, and provide access to them for cleaning and repairs.

Funnel; *Smoke-Stack* or *Smoke-Pipe.*—The passage through which the gases and smoke coming from the uptakes are led to the outer air. In natural draft the use of the funnel is to provide a column of relatively hot gas. The draft pressure is then the difference in weight between a column of hot gas of cross-section one square inch and of height equal to that of the funnel above the grates, and the weight of a similar column of outside air. The funnel is usually circular in section, and extends to a height of from 50 to 80 or 100 feet above the furnace grates. Funnels usually made of double thickness, sheet steel, with an air space between, the better to prevent radiation and loss of heat, and a cooling of the gases before they have reached the top. Occasionally the funnels are of elliptical or oblong section, in order to oppose less air resistance to the motion of the ship. The cross-sectional area of the funnel should be from 1-7 to 1-9 of the grate surface, or slightly less than the cross-sectional area through the fire-tubes.

Funnel Cover or **Hood.**—A cover placed over the top of the funnel when the ship is laid up for any length of time.

Funnel Guys or **Stays.**—Guys or stays, usually of wire rope, for supporting the funnel in place. They run from the top or upper part of the funnel to the deck or rail of the ship.

Furnace.—The part of the boiler which contains the burning coal, and from whence the hot gases pass to the tubes. See under *Boiler*.

RECENT PUBLICATIONS.

THE SLIDE RULE. By Charles N. Pickworth. D. Van Nostrand Co., New York. Fifth Edition. Size 5 by 7 1-2. Pages 88. With illustrations. Linen covers.

This is one of the clearest expositions of slide-rule practise within the reviewer's ken, and should meet with a hearty welcome from students and practical workers. The language is unaffected and the explanations are concise and direct as well as lucid. The text is logically arranged; an explanation of the mechanical and mathematical principles of the slide rule precedes a description of the Mannheim rule and an explanation of its notation. This is followed by a table of conversion factors and instructions in the practical use of the slide rule, the latter including copious numerical examples. A short discussion of circular calculators of the watch (Boucher) and long-scale types and special rules for limited application completes the book.

Lean's Royal Navy list has completed the twenty-first year of its existence, during which time it has steadily grown in the confidence of those who seek accurate information in its pages. It is issued quarterly, and the latest issue, now before us, is divided into chapters containing: Seniority list of all British naval and marine officers on the active and retired lists; lists of all the vessels of the British Navy, giving officers and station; lists of officers of the Royal Naval Reserve, and naval officers at the shore stations, and a complete record of war services, rewards, etc., of officers on the active and retired lists of the Royal Navy and Royal Marines. For those who require information on the subjects mentioned, this publication is indispensable. The publishers are Witherby & Co., 326 High Holborn, London, W. C., and the selling price is 7s. 6d. per copy, or £1 7s. 6d. annually in advance.

The prospectus for the twenty-fifth volume of the Proceedings of the U. S. Naval Institute contains a number of extremely interesting papers which will be published during the coming year. Among those treating of war subjects are: "Cable Cutting Operations During the Spanish War," by Capt. C. F. Goodrich, U. S. N.; "The Battle of Manila Bay," by Lieut. C. A. Calkins, U. S. N., and "The Location of Cervera's Fleet," by Lieut. Victor Blue. No. I. of this volume contains much exceptionally interesting matter concerning the Spanish-American War. Copies can be ordered from the Secretary and Treasurer, U. S. Naval Institute, Annapolis, Md. Single copies are $1 each and the annual subscription for non-members is $3.50.

Captain Henry A. Bourne, president of the Old Dominion Steamship Co., died at his residence in Brooklyn late in April, aged 70 years. He had followed the sea all his life, and at the close of the Civil War he entered the service of the Old Dominion Steamship Co. as Captain of the steamship *Albemarle*. He was thereafter master of various vessels owned by the company, and in 1876 was appointed general superintendent. Later he was made general manager, and then in succession he was elected vice-president and president of the company. Those who knew him best speak of him with admiration, and his reputation among those interested in marine affairs as a liberal, sympathetic and upright man was widespread. To his executive ability the splendid daily services of the company bear witness. The vacancy caused by his death has been filled by the unanimous action of the board in the election of William L. Guillaudeu, for many years vice-president and general manager. This is a well earned honor, as Mr. Guillauden has been in the service of the company since boyhood. He has filled every position in the office of the company where ability and a steady attention to duty were demanded, and his final advancement is the capstone to an honorable business career.

TRADE PUBLICATIONS.

Users of fire hose who have not been satisfied with the quality of the hose used will take a hint from a circular issued by the Boston Belting Co., 256 Devonshire street, Boston, Mass.

A new line of grate bars is just being offered and is illustrated in a circular issued by the manufacturers, Neenes Bros., Troy, N. Y. These are designed for either soft or hard coal. The type of the grate is illustrated in the circular.

The Jennings combined steam separator, also reducing valves and other steam specialties, have a catalogue devoted to them, issued by Watson & McDaniel Co., Philadelphia, Pa. Each specialty is thoroughly illustrated and described.

Portable bellows forges is the subject matter of circular *B*, issued by the Crumlish Forge Co., Buffalo, N. Y. The portable forge is illustrated and a brief description given, together with a number of testimonials from shipbuilders and others.

A neat folder which, when opened up showing a number of yachts sailing before a stiff breeze, illustrating Lundell fan motors, is a souvenir for which all interested will wish to send for to the Sprague Electric Co., 20 Broad street, New York.

The Gumphert grate is a recent invention offered by the Gumphert-Marrin Engineering Co., 302 Chestnut street, Philadelphia, Pa. It is a type of grate which has been much used in marine work, and sectional drawings and other engravings are given, showing the application.

Centrifugal pumping machinery manufactured by the Kingsford Foundry & Machine Works, Oswego, N. Y., is described in a very neatly printed and illustrated catalogue devoted to them. Besides a description of the various types of pumps, there are price lists, speed and other tables which are of much interest.

A new brand, "High Grade" yellow metal bolts, sheathing and plates, is offered by the U. T. Hungerford Brass & Copper Co., 121 Worth street, New York. Shipbuilders and others who are users of these specialties will find these circulars of much interest, especially as they give a list of many other brass and copper goods manufactured by this company.

A large pamphlet has been issued by the Daimler Motor Co., Steinway, Long Island City, N. Y., giving many testimonials of the excellence of launches and engines manufactured by this company. These letters will be well worth perusal by any of our readers who contemplate purchasing an engine or launch, as the letters come from all parts of the country.

The subject of graphite for lubricating gas engine cylinders, valves, pistons and other small or close-fitting bearings is well discussed in a four-page circular issued by the Joseph Dixon Crucible Co., Jersey City, N. J. The subject is handled in such a manner that all who read the circular will wish to send for the larger pamphlet entitled "Graphite as a Lubricant."

Lundell fan motors are superbly illustrated in one of the the most handsome catalogues we have received, issued by the Sprague Electric Co., 20 Broad street, New York. It covers the subject very thoroughly and the illustrations are exceptionally fine. Attention is also given to the small exhaust fans. Copies can be had by referring to Marine Engineering.

The hydraulic steering engine and duplex steam pumps manufactured by the Queen City Engineering Co., Buffalo, N. Y., are illustrated and described in considerable detail in a pocket-size catalogue just issued. Other subjects referred to are boiler feed pumps, tank pumps, single-cylinder high pressure pumps, etc. Copies of the catalogue can be had from the company upon application.

Propeller wheels of the "perfected outward thrust" type, as designed and manufactured by A. Wells Case & Son, Highland Park, Conn., have a very well-printed and thoroughly illustrated catalogue of nearly 100 pages devoted to them. Many testimonials are given; also many pictures of yachts and other vessels. Copies of this catalogue can be had by any of our readers by writing for them and mentioning Marine Engineering.

A catalogue is sent free to all inquirers by the Boston & Lockport Block Co., 142 Commercial street, Boston, Mass., descriptive of this company's blocks and other marine specialties. The catalogue is very complete, and each article is illustrated and accompanied by full information. Any one who has need for specialties of this kind will find this catalogue particularly valuable for reference, especially for the large list of subjects it covers.

Blue printing apparatus of all kinds is fully described in circulars and cards issued by the F. W. Emerson Mfg. Co., 27 Mortimer street, Rochester, N. Y. The latest card issued shows a large printing frame on a car for easy handling, and other specialties. These cars and frames have recently been supplied in large numbers to the United States Government and to many prominent engineering concerns; also many large detail tables, of which this company makes a specialty.

A circular from the Taunton Locomotive Mfg. Co. regarding the Wainwright appliances gives information regarding the opening of the New York office in the Singer Building, under the management of Charles H. Paine. The latest catalogue, *E*, is now ready, containing illustrations and full information regarding the Wainwright feed water heaters, surface condensers and expansion joints. Copies of this catalogue can be had from the home office in Taunton, Mass., or from Mr. Paine.

Electric fans made by the Diehl Mfg. Co., Elizabethport, N. J., have a very attractive catalogue devoted to them. These fans include ceiling and column fans, brackets, ventilating fans, etc., all of which are illustrated and have much descriptive matter devoted to them. This company has recently begun the manufacture of a direct connected electric plant, the general type of which is shown in the advertisement elsewhere. Fuller information can be had by applying to the company.

Rolled steel floor plates for floors and steps in engine rooms are well illustrated and described in a catalogue issued by Taylor & Lewis, Lewis Building, Pittsburg, Pa. It is claimed in the catalogue for these plates that steel has advantages over cast iron in that it is much lighter and stronger and quite impossible to break under ordinary stress. Should it be bent it can be readily straightened. The subject is one that will interest many of our readers, and copies of the catalogue can be had upon application.

Pipe Threading Machines.—Marine engineers and those in charge of machine and repair shops, whether ashore or afloat, will be interested in the catalogue recently published by the Merrell Mfg. Co., Toledo, Ohio, concerning their pipe threading and cutting machines. In the advertisement, this company illustrates its No. 5 portable hand machine. On this, power is applied by either crank or ratchet lever to the shaft of the pinion, which engages the geared wheel enclosing the dies. The gears are completely housed from dust and chips. These machines have the Standard adjustable quick opening and closing die head and improved cutting-off knife. The chasers are five in number on Nos. 5 and 6 machines and six on No. 9. They are set by graduation to any size desired, are released from threading while in motion, opened to permit the pipe to cut off and closed instantly and positively, one set being used to thread several sizes of pipe. These are only a few desirable features of this machine, which is described in full by catalogue, copies of which can be had upon application by mentioning Marine Engineering.

Song of the Canalman.

The battleship's majestic bow,
May plough the stormy main;
The ocean greyhound's iron prow
May cleave the sea in twain;
Yet I'd not give my little ship
For any in the bay:
Come to me in Coentie's slip,
Where lies the Maggie May.

The Maggie May is long and lank,
Her engine is a mule;
I keep her gunnels close to bank,—
Her rudder feels my rule.
In summer, when the warm winds blow
Across the new-mown hay,
I sail to far off Buffalo
Upon the Maggie May.

But winter finds us here again,
In old Coentie's slip.
My cabin is the snuggest den
That e'er adorned a ship,
With lockers full of meat and pie
To nibble night and day;
And 'near the bunk, a jug of rye—
Long float the Maggie May.

But I've been thinkin' some of late,
'Bout makin' other plans;
In fact I need a good first-mate
To wield my pots and pans;
To bake my bread—my salt-hoss fry;
Who will not say me nay?
If there be such, she may apply
To me and Maggie May.

—*George A. Beckenbaugh.*

BUSINESS NOTES.

Increased Facilities.—The Frasse Co. has recently removed from 19 Warren street to 38 Cortlandt street, New York, in order to secure more facilities. This company carries a full line of tools for machinists and engineers.

Marine Glasses.—One of the largest stocks of marine glasses in the country is carried by the Spencer Optical Mfg. Co., 15 Maiden Lane, New York. This company also has the sole agency for the Andemair's field and marine glasses. Circulars and information regarding any of the goods handled by this company can be had upon application.

The Spedden Co.—The Spedden Co., Baltimore, Md., is busier than at any time in its history. One of the latest reports stated that that there were six tugs and steamers at the yards. Besides this work the company was recently awarded a contract for a dispatch boat by the Government. and recently received a contract to rebuild the S. S. *Bluefields.*

Garlock Packings.—The Garlock Packing Co., Palmyra, N. Y., commenced business in a small way, nearly a quarter of a century ago, with one fixed principle in view, namely, that all of its productions should be of a superior quality. From the fact that the business has doubled every year from the commencement, it is self-evident that the goods have met with favor among engineers. Their annual output now numbers many thousands of tons.

Boiler Compound.—The subject of keeping marine boilers free from incrustation and galvanic action has led to the establishment of a special department by the Dearborn Drug & Chemical Works, Rialto Building, Chicago, Ill., under the charge of E. P. Gould, a well-known lake engineer. The subject has been carried out in detail in its application to steamboat service on the Great Lakes, but has only recently been extended to the salt water service. Circulars and other information regarding this new departure can be had upon application to Mr. Gould, care of the company.

Change in Name.—Owing to a recent decision of the court the Lee-Penberthy Injector Co., Detroit, Mich., has dropped the name Penberthy, and will hereafter be known as the Lee Injector Mfg. Co., and the injectors will be sold as the Lee.

Free Samples.—The seam composition for filling cracks and checks in masts, beams, rails, etc., manufactured by Cole & Kuhls, foot of Twenty-fourth street, Brooklyn, N. Y., has been thoroughly tested on yachts and vessels for many years, and in order to increase its use the manufacturers offer to send free samples to anybody who will write for them.

Joy Inventions.—Messrs. David Joy, Son & Pryor have appointed Thorpe, Platt & Co., 97 Cedar street, New York, American agents for their assistant cylinders for valve gears, which have become so extensively used. Among the ships recently fitted with this system is the *Kasagi*, built by the Cramp Co. for the Japanese navy. The new agents will be prepared to give any information to inquirers regarding this specialty.

Union Steam Pumps.—A recent copy of the "Journal," Battle Creek, Mich., gives an interesting article regarding the development of the Union Steam Pump Co., showing the steady growth from a small establishment to the large concern which now gives employment to many mechanics. An addition has recently been built to the works increasing the shipping facilities and making the handling of heavy pumps much easier. The general type of this company's pumps is shown in the advertisement elsewhere in this issue.

National Pneumatic Tools.—The pneumatic tool business has been especially brisk of late, particularly so with the National Pneumatic Tool Co., 18 South Fifteenth street, Philadelphia, Pa. This company recently succeeded to the business of the Haeseler Co., and its business the first month was four times that of the previous company in its best month. Besides orders from many large manufacturing establishments, ten tools were sold to the Atlantic Works, East Boston, Mass., and to other shipbuilding companies.

Education by Correspondence.—Attention is called to the announcement in this issue of the American School of Correspondence, Boston, Mass. The school offers special advantages to readers of Marine Engineering to secure an education, enabling them to pass Government examinations. The object of the school is to give the busy man a thorough training in steam, electrical and mechanical engineering by mail. The steam engineering courses are carefully supervised by experts and are in close touch with the developments of the age. The instruction is carefully graded, thoroughly practical and scientific, and is intended to give engineers a complete technical training. The school is chartered by the Commonwealth of Massachusetts, and is strictly an educational institution and not a money-making enterprise, therefore the tuition fee is placed within the reach of all wage-earners. Engineers will do well to write for a handbook.

A Large Order.—The William H. Horstmann Co., Philadelphia, Pa., has recently been awarded an order by the Army Quartermaster for 100,000 hats. It will be remembered that this company makes a specialty of uniforms, hats, flags, etc.

Cape Cod Folding Anchors.—Yachtsmen will be interested in the Cape Cod folding anchor, which is being put on the market by Wilcox, Crittenden & Co., Middletown, Conn. Circulars and full information are issued by the company and can be had upon application.

Chicago Office of the C. & C. Co.—The new office of the C. & C. Electric Co. in Chicago will be at 828 Monadnock Block, where Mr. E. Sanderson, the company's new manager, will be glad to welcome all the old friends and customers of the company. Mr. Sanderson will look after all the territory tributary to Chicago.

Electrical Instruments.—Owing to the great demand for its various kinds of electrical instruments, of the Weston Electrical Instrument Co., Newark, N. J., has been obliged to build an entirely new factory at Waverly, N. J. This establishment when finished will be one of the most complete manufacturing plants in the country.

Morse Iron Works.—The U. S. transport *Hooker*, formerly the Spanish steamer *Panama*, which has been made a cable ship by the Government, was refitted at the Morse Iron Works, foot of Twenty-sixth street, Brooklyn, N. Y. She is now a first-class cable ship, and will be employed by the Government in laying cable at the Philippine Islands.

A Large Order for Babbitt Metal.—Merchant & Co., Philadelphia, Pa., recently received an order for a carload of their well-known babbitt metal. There has also been a large demand for this company's well-known iridium anti-friction metal. This is a mixture which many of our readers interested in babbitt should write to this firm to inquire about.

Indicator Work.—Everything necessary for indicator work is the special business of Richard Thompson & Co., 120 Liberty street, New York, who handle the Bachelder adjustable spring indicator and the Ideal reducing wheel. This company also sells the well-known Thompson grate bars and Thompson patent "soot sucker" boiler tube cleaner, which has been on the market for some years. Circulars regarding these specialties are issued by the company.

A Fine Electric Plant.—The Bullock Electric Mfg. Co. moved into its plant at Norwood, a suburb of Cincinnati, in December, and at present, although the increased facilities have more than trebled the output, it has so much work ahead that the shops are now working night and day. When this firm had its factory in Cincinnati it was recognized as one of the large electrical establishments, but the new plant is believed to be, next to the General Electric Co. and the Westinghouse Mfg. Co., the largest electrical establishment in America. No plant is better equipped for turning out work. All machine tools are driven with individual motors, and the entire absence of belts and shafts makes it a novel factory which is well worth a visitor's time to inspect.

ZINC WHITE IN MARINE PAINTING.

Within a few years after the discovery of the modern process for making zinc white, the French naval authorities, after severe tests, ordered its use to the exclusion of white lead on the interior of all vessels of the French navy. Experience has confirmed its superiority for painting structures exposed to sea-air and sea-water, and the French navy as well as the French steamship companies now universally employ it, while it is also the official base for painting lighthouses and Government work on the seashore. The French Marine authorities also use it for painting galvanized iron plates, the hulls of torpedo boats, the shells of metal pontoons, etc.

That the French navy should have been earliest to adopt this practice is natural, since zinc white was first generally introduced in France. But the naval authorities of the United States, having made their own experiments with the same results, have adopted zinc white as the fixed component of all paints used either in the Navy or by the Lighthouse Establishment. The famous "White Squadron" obtained its color from zinc white, and remained white because zinc does not change color. Ten tons of American zinc white is the cruising allotment for each ship, and it is used liberally and effectively.

Similar testimony is found in the U. S. Lighthouse specifications, which require, for white, a mixture of one-fourth lead and three-fourths zinc, and for tinted paints, American zinc white and yellow ochre, with no lead. "The colored paints are wanted for outside use and are required to withstand the bleaching effects of salt water and sunlight."

The durability of zinc white is due to its chemical stability and to the large proportion of oil it carries to the painted surface. No other white pigment approaches it in this respect. It is the one white paint material that is capable of resisting salt water and salt air. Added to other materials it shields them and gives them durability.

Advt. NEW JERSEY ZINC CO.

The Warren Steering Gear.—This steering gear, which was formerly manufactured by the Marine Machine & Conveyor Co., will now be put on the market by F. C. Sayles, a capitalist of Pawtucket, R. I., who has bought out the company. It is understood that he will reorganize the company and increase the manufacturing facilities so that this steering gear may be given its proper place in the shipbuilding world.

Hydraulic Tools.—William H. Wood, Media, Pa., who makes a specialty of hydraulic tools, has recently filled several large orders, among them a riveting plant for Thompson Kingsford, Oswego, N. Y., whose marine boilers are well known to our readers; a large hammer for the Navy Yard on Puget Sound; several large traveling cranes for the Burlee Dry Dock Co., Port Richmond, N. Y., together with many other tools to concerns which build boilers and do other work, but which are not marine.

PARAGON BOILER.—We are informed by Capt. M. DePuy, 19 South street, New York, that he has closed an arrangement with the Marine Iron Works, Chicago, Ill., by which they have the shop rights to build the Paragon boiler for a term of five years.

BIG ENTERPRISE IN HAVANA.—Krajewski, Pesant & Co., 32 Broadway, New York, and proprietors of the Erie Basin Iron Works in Brooklyn, are reported to have purchased a large amount of land across the bay from Havana and have engaged Andrew Gunderson to go to Havana as resident manager of the new plant. Mr. Gunderson will have the supervision of the construction of a floating dry dock with a metal sheathed bottom, 220 ft. long and 90 ft. wide on the floor. In addition to the dry dock, plans are drawn for a pier at Regia, 276 ft. long, which will be pushed rapidly to completion, where ships of large draught will be enabled to unload. Mr. Gunderson will also have charge of the construction of modern machine shops, boiler shops, electrical works and brass and iron foundries.

THE U. S. METAL POLISH.—This polish is a fluid which gives quick results, and which is particularly well adapted to outside work in cold weather as well as hot. It is manufactured by George W. Hoffman, 295 East Washington street, Indianapolis, Ind., who will send circulars upon application.

CONSOLIDATION OF PNEUMATIC INTERESTS.—The Pneumatic Supply & Equipment Co. has been organized under the laws of the State of New York, and has opened an office at 120 Liberty street, New York. It is the purpose of this company to deal generally in compressed air equipment, and it will make a specialty of the installation of complete plants. Mr. J. W. Duntley, the president of the Chicago Pneumatic Tool Co., is the president of the new company; Mr. E. B. Gallaher, formerly with Messrs. Patterson, Gottfried & Hunter, is the vice-president and engineer, and Mr. W. P. Pressinger, formerly manager of the Clayton Air Compressor Works, is the secretary and treasurer.

SEARCH LIGHT PROJECTORS.—The Carlisle & Finch Co., Cincinnati, manufacturers of electric search light projectors, report business as excellent. It has lately secured orders for several large projectors for the U. S. Navy, as well as a large number for use on the lakes, Pacific Ocean and Western rivers. The projector made by this company will burn in any position and the arc is always maintained at the proper length, irrespective of friction of the mechanism or dirt on the moving parts. This company reports that its search lights are in use on all the Western rivers, and that some of the largest steamboat companies have adopted them exclusively.

A SHIPBUILDING RECORD.—The Harlan & Hollingsworth Company, Wilmington, Del., in the year 1898-9 has exceeded in the amount of construction all previous years. It has launched or contracted for nine coastwise steamers, one river steamer, one yacht, three ocean-going tugs and three torpedo boat destroyers, seventeen in all; steel steam yacht Niagara for Mr. Howard Gould, of New York City, triple expansion surface condensing engines; thirty knot torpedo boat destroyer Stringham, for U. S. Government, two triple expansion surface condensing engines, four Thornycroft boilers; steel sea-going propeller tug boat Gettysburg, for the Reading company, one triple expansion engine; steel twin screw steamer Tennessee, for the Baltimore Steam Packet Company; steel single screw freight steamer S. T. Morgan, for the Virginia-Carolina Chemical Company, Richmond, Va., triple expansion surface condensing engine; steel single screw sea-going tug Valley Forge, for the Reading Company, and exact duplicate of the Gettysburg; steel harbor tug Gem for the Standard Oil Company, of New York; steel single screw coastwise steamers Kershaw and Nantucket for the Merchants and Miners Transportation Company, triple expansion surface condensing engines; two thirty-knot torpedo boat destroyers, Hopkins and Hull, two direct acting triple expansion engines, four Thornycroft boilers; two single screw freight and passenger steamers Ponce and San Juan, for the New York & Porto Rico S. S. Company, triple expansion surface condensing engines, Ellis & Eaves induced draught; single screw freight and passenger steamer Maracaibo, for Messrs. Boulton, Bliss & Dallett, Red D Line, triple expansion surface condensing engine; single screw freight and passenger steamer known as Winsor Ship No. 4, for the Boston and Philadelphia S. S. Company, inverted triple expansion engine; two freight steamers for the outside line between New York and Baltimore, for the New York and Baltimore Transportation Line, triple expansion engine. Congress, at last session, made a very large appropriation for widening the Christiana river and deepening it to a uniform depth of twenty-four feet at mean low water, and as there is a rise and fall of between six and seven feet in the tide at Wilmington, the Harlan & Hollingsworth Company contemplate building a 600-ft. ways.

SPECIAL NOTICES.

Announcements under this heading will be inserted at the uniform rate of thirty-three-and-a-third cents a line. Lines average ten words each.

TRIPLE EXPANSION ENGINE FOR SALE.

A fine new 4-cylinder triple expansion engine, cylinders 18.26½ and two 27 lows x 18 stroke. Suitable for yacht. Can be bought cheap. ALFRED BOX & CO., Front and Poplar Sts., Philadelphia.

COPPERSMITH FOREMAN SEEKS POSITION.

Situation wanted as foreman in coppersmith work, by man of many years' experience in government and merchant marine work.
COPPERSMITH, care MARINE ENGINEERING,
World Building, New York.

BARGAIN IN STEAM YACHT.

A fine yacht, 50 feet over all. Able seaboat, compound engine, water-tube boiler, quarter boats, awning, and everything complete; for sale at a great bargain.
STEAM YACHT, care MARINE ENGINEERING,
World Building, New York.

SEPARATORS FOR WAR VESSELS.—The Harrison Safety Boiler Works, Germantown Junction, Philadelphia, Pa., have just supplied the U. S. Government three separators for the vessels captured from Spain during the war in Cuba.

SCHOOL OF NAVIGATION.—A school of navigation, under the charge of R. M. Pugsley, 146 West Twenty-third street, New York, offers a course preparing candidates to pass all the requirements of the U. S. Local Inspectors of Steam Vessels.

BEARING METAL.—We are informed by J. J. Ryan & Co., 68 West Monroe street, Chicago, Ill., that they had an experience with the bearing-crank pin-box on an engine which was continually running hot under heavy loads. This firm applied its well-known Nickel brand of babbitt metal where the trouble was experienced, and no further trouble resulted. This firm has established a large trade with shipbuilders and builders of engines.

BELKNAP ELECTRICAL SPECIALTIES.—Owing to the large demand for their various specialties, the Belknap Motor Co., Portland, Me., has opened an office at 9 Maiden Lane, New York, under the charge of A. W. Koenig, who will handle the Chapman voltage regulator, electric controllers and direct connected electric plants manufactured by this company. Among the specialties is a marine motor of the multipolar type, such as is now in use on many Government vessels, and which is especially adapted to hoisting anchors, boats, sails, etc.

ALCO VAPOR LAUNCHES.—The Marine Vapor Engine Co., Jersey City, N. J., has never been busier than this spring. Among recent orders are a 21 ft. carvel launch with 3 horse power alco vapor engine, for C. H. Thompson, Brattleboro, Vt.; an 18 ft. yacht tender for schooner yacht *Katrina*. The gratings of this boat are American elm, and the engine is a 3 horse power alco vapor. The company also has an order for a 26 ft. launch for the U. S. Revenue Cutter Service, with awnings, storm cushions, pantasote cushions, and to be equipped with a 5 horse power alco vapor engine.